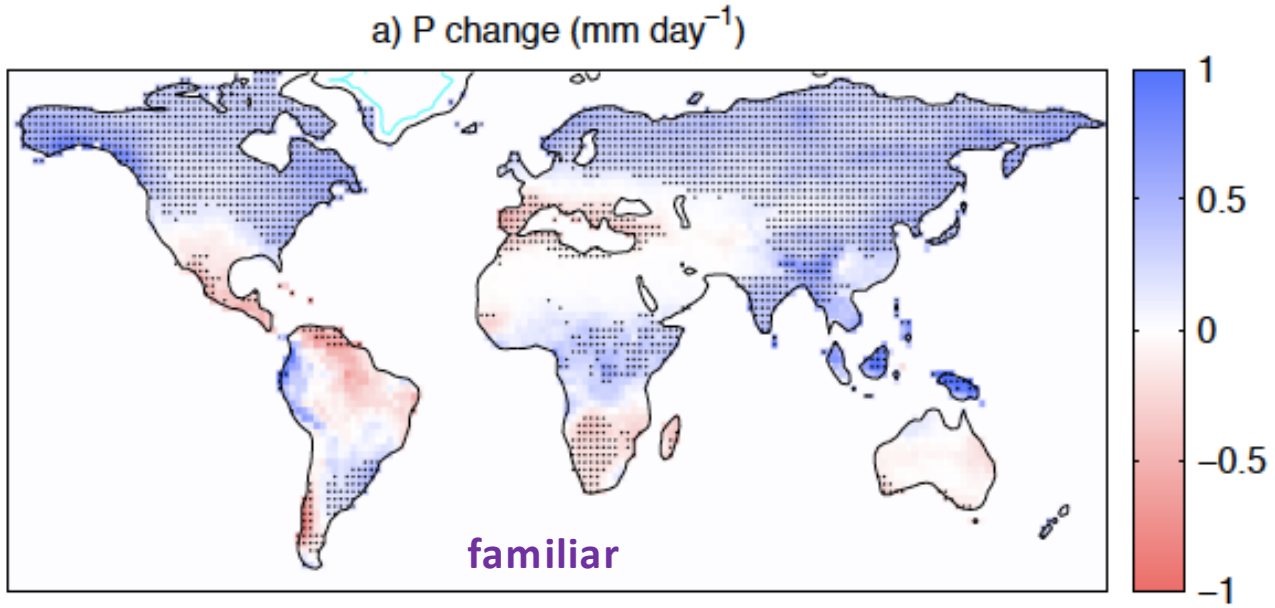
Different hydrologic impacts respond very differently to warming

In **observations** (historical & paleo) as well as models

Jack Scheff (UNC Charlotte), with thanks to many

2018, *Current Clim. Change Reports*; 2017, *J. Clim.*

rcp8.5 CMIP5-median 21st century…



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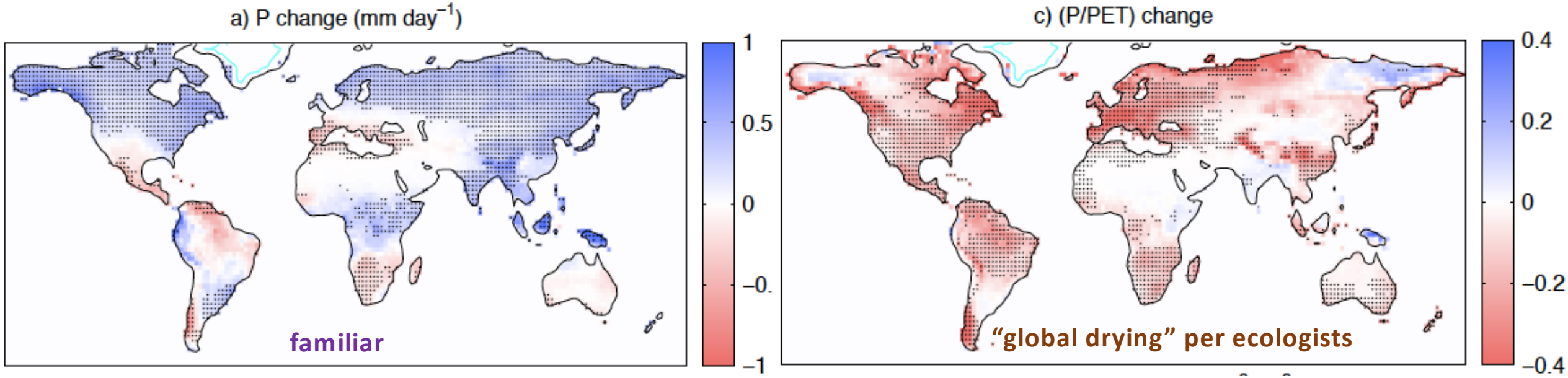

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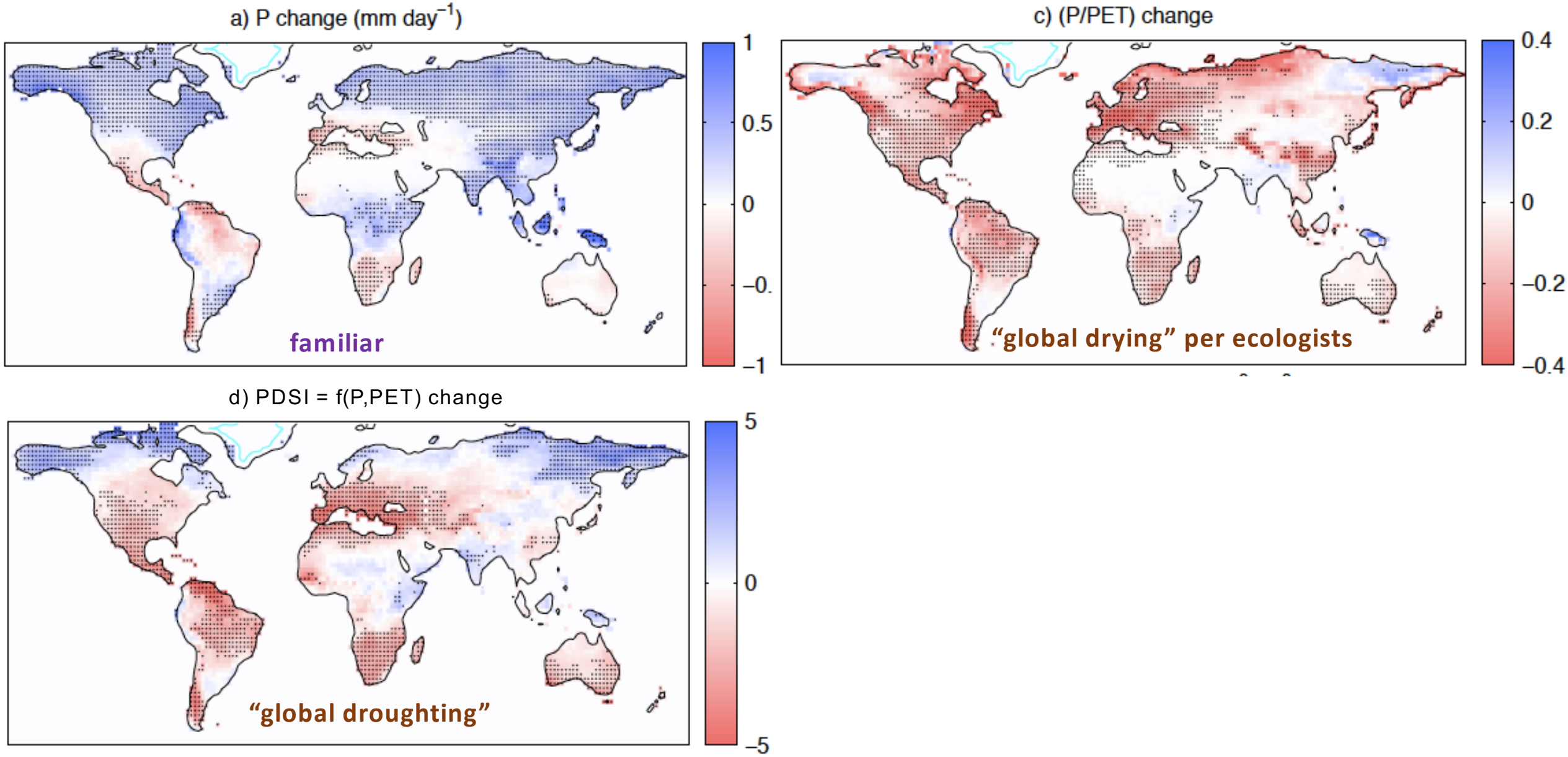

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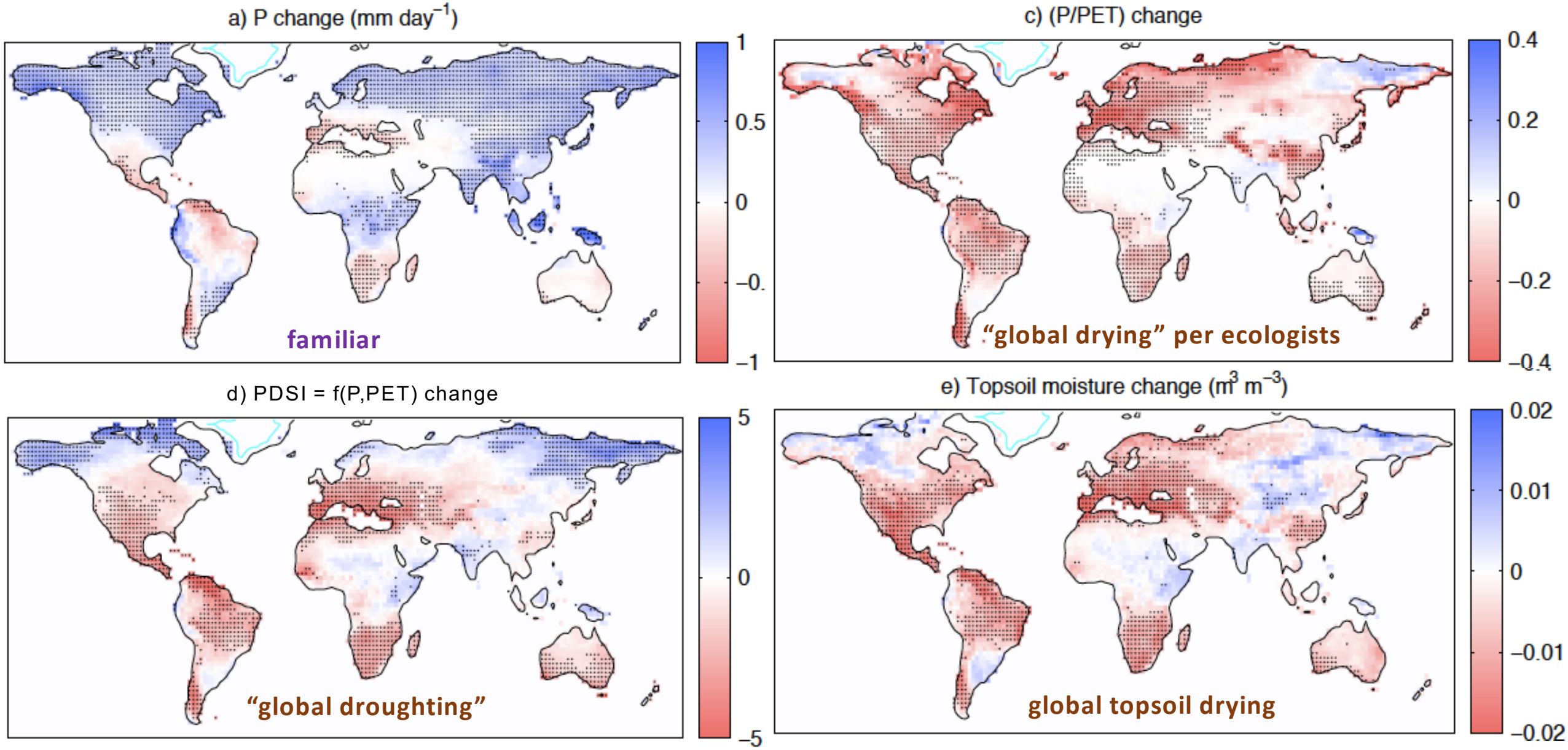

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- Also - increases in SH at expense of LH – leads to heatwaves & increased T variance

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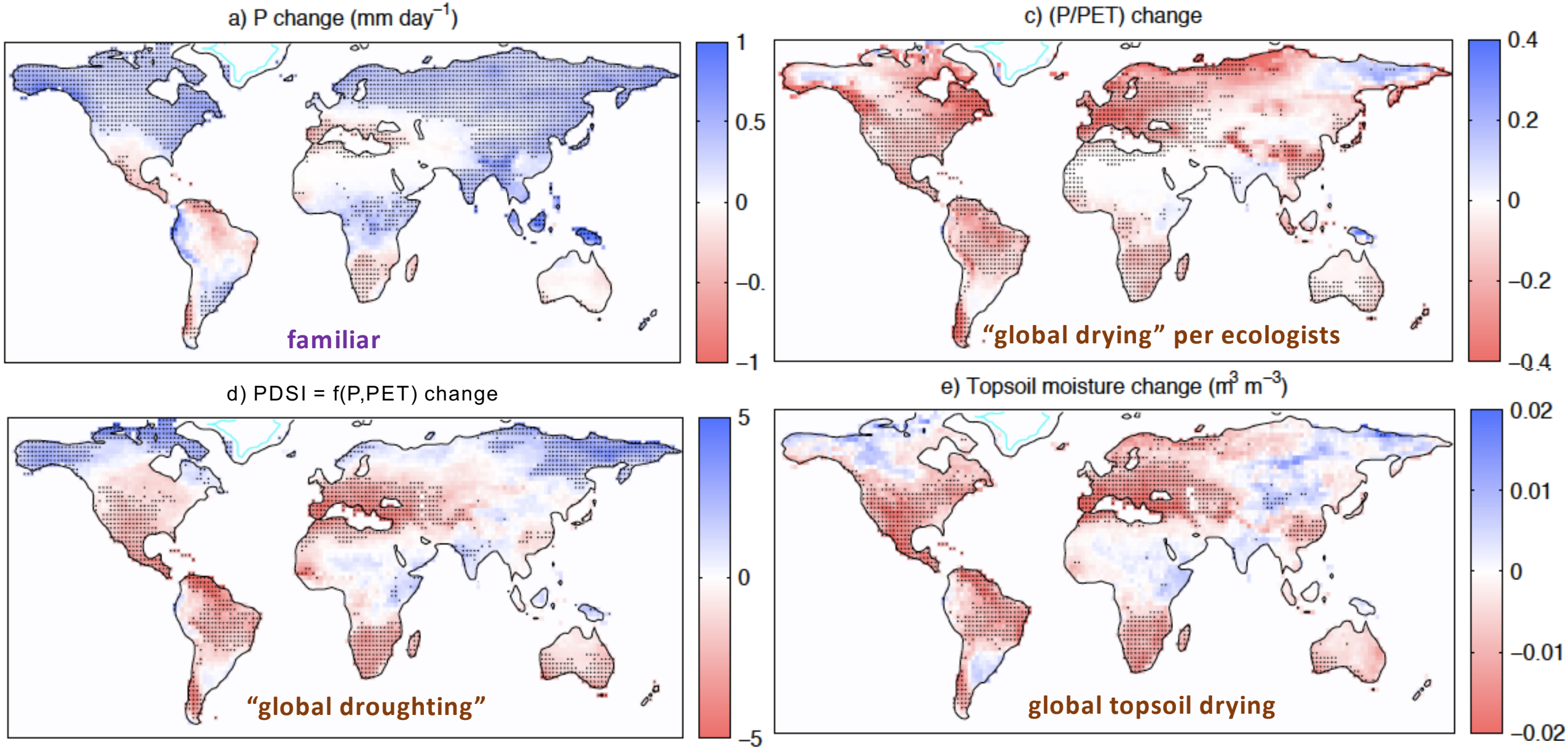

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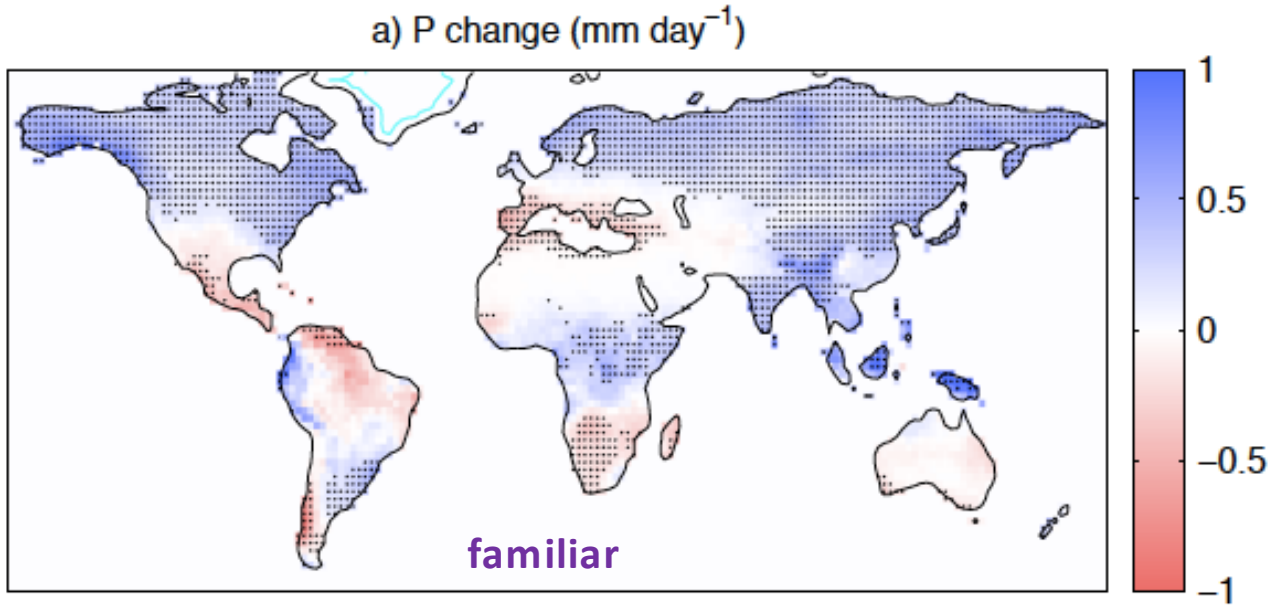

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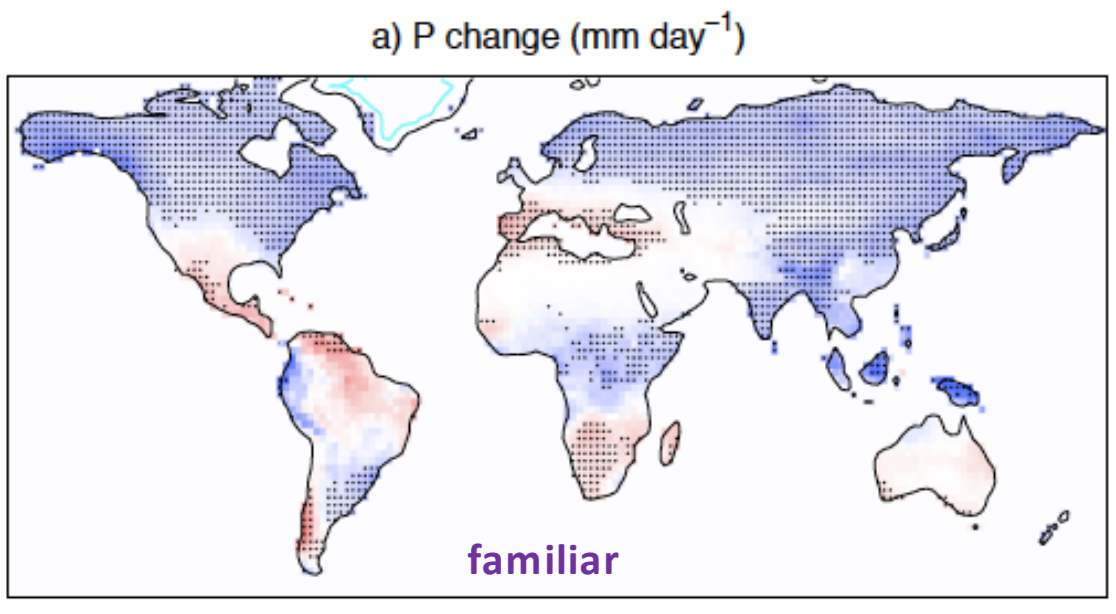

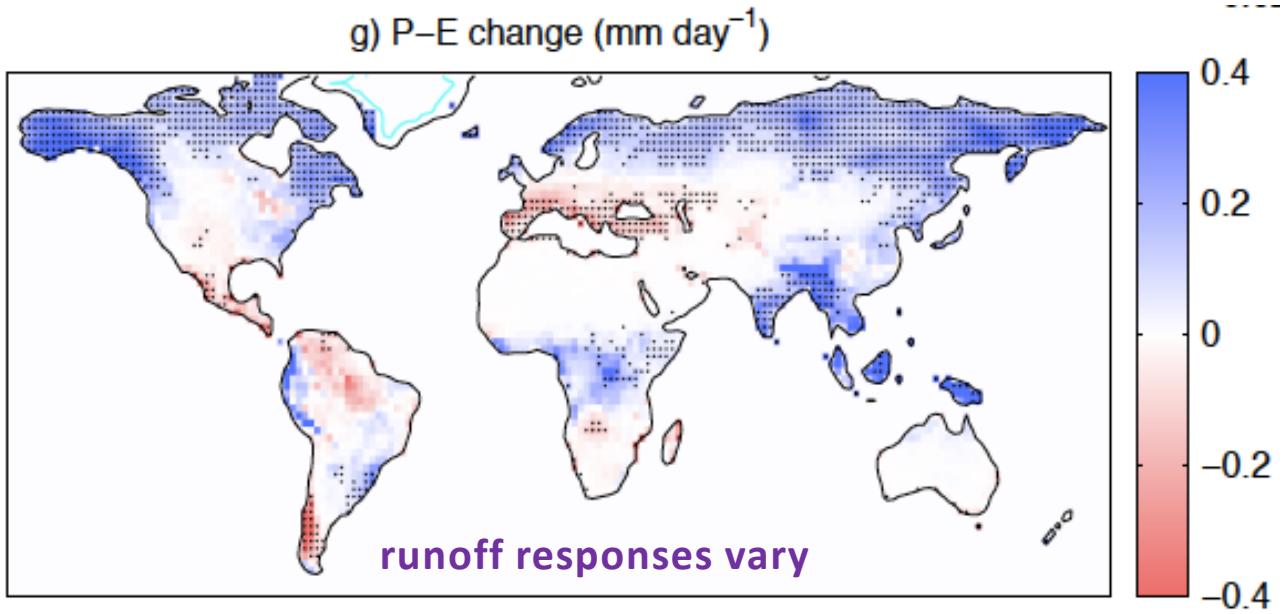

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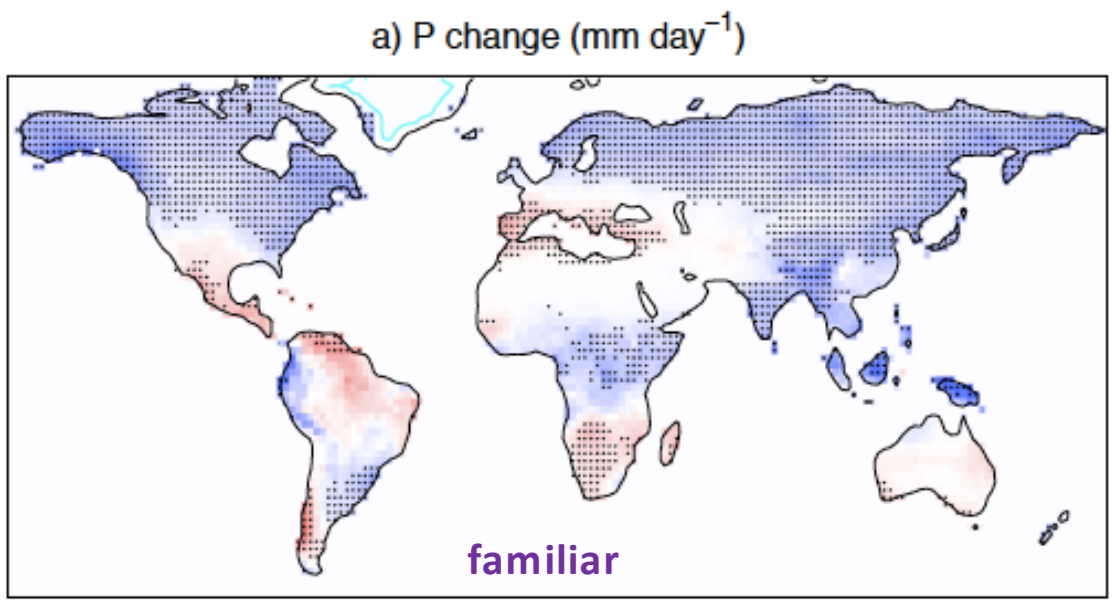
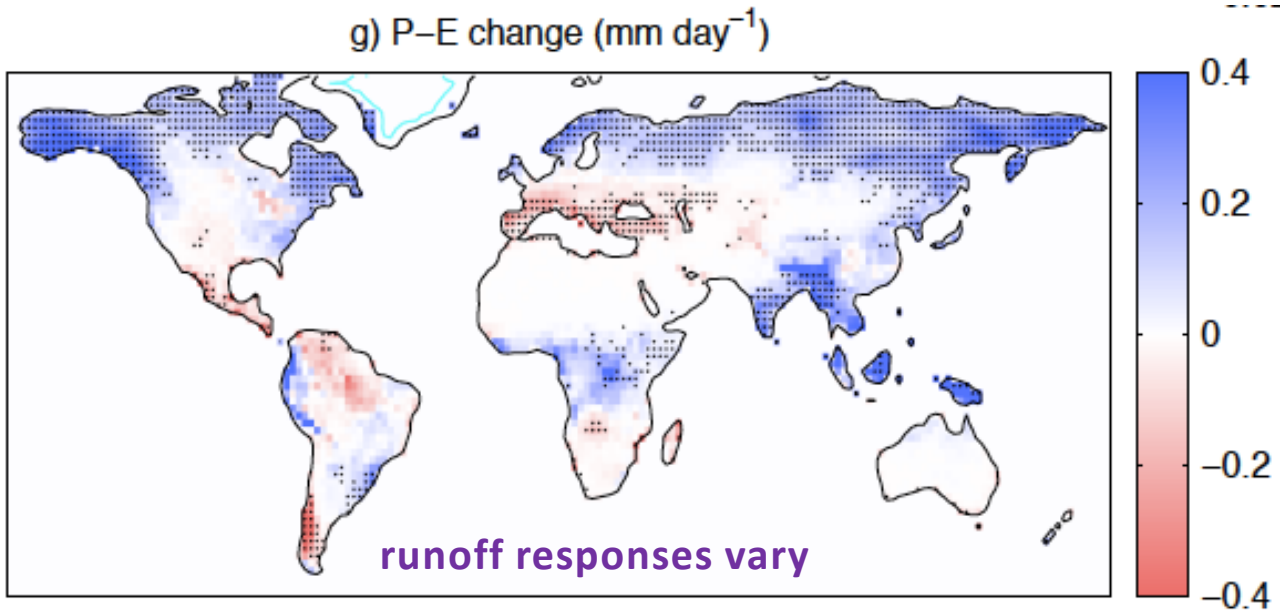
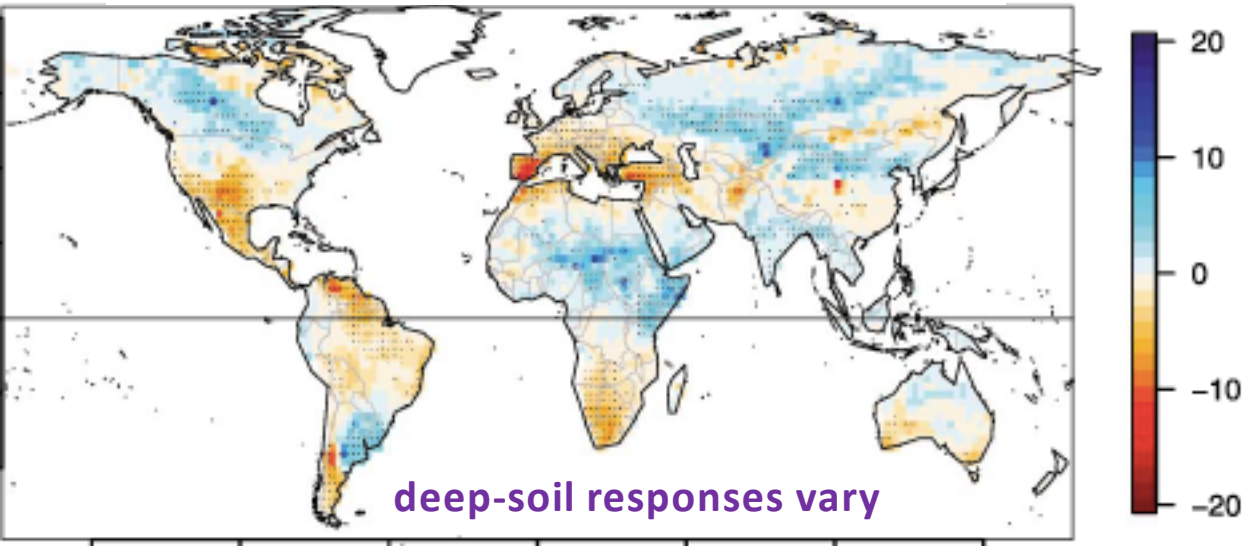




3m soil moisture % change (from Berg et al 2017)



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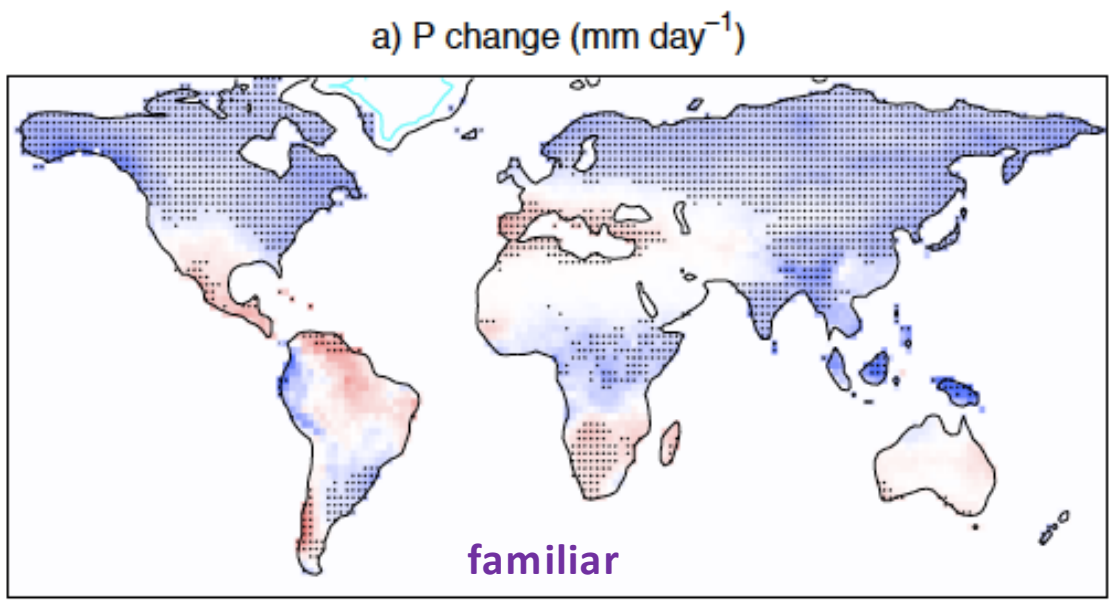

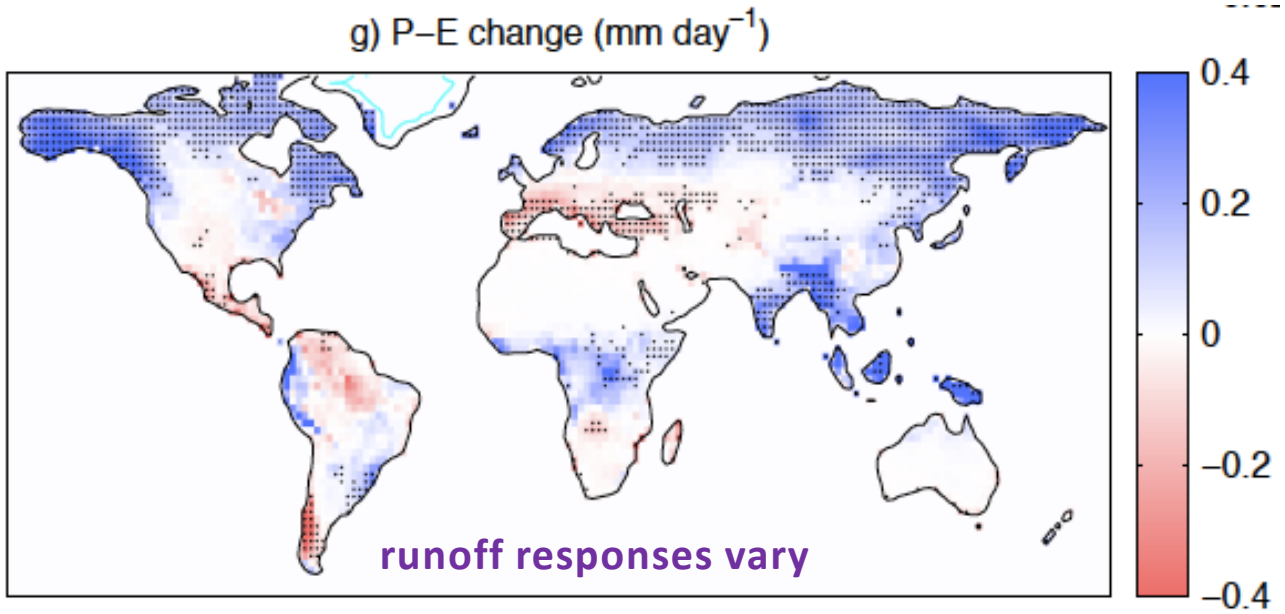

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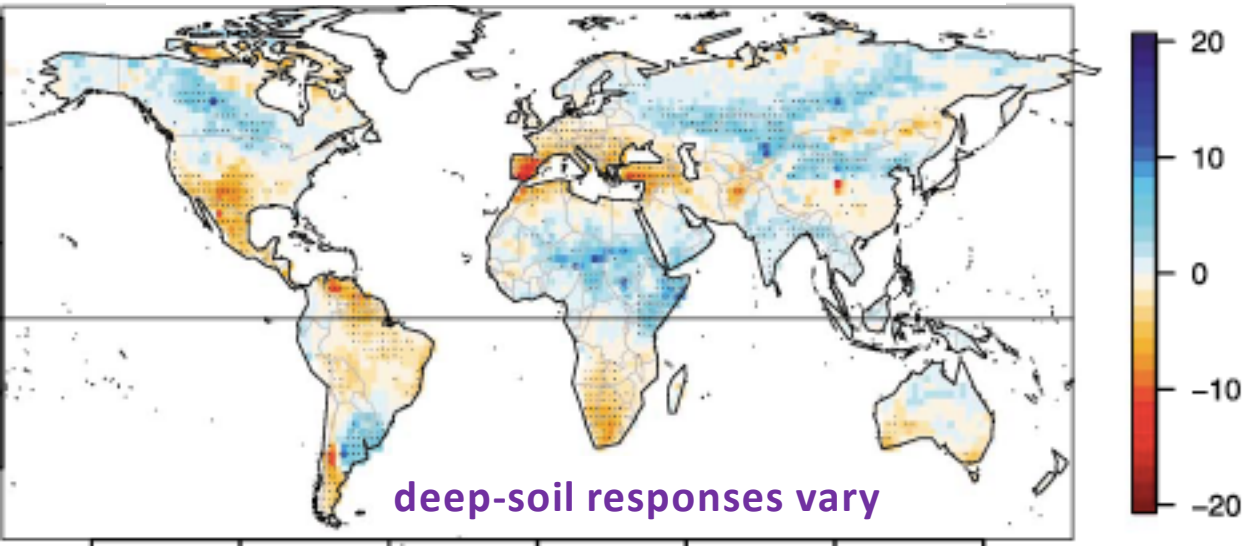

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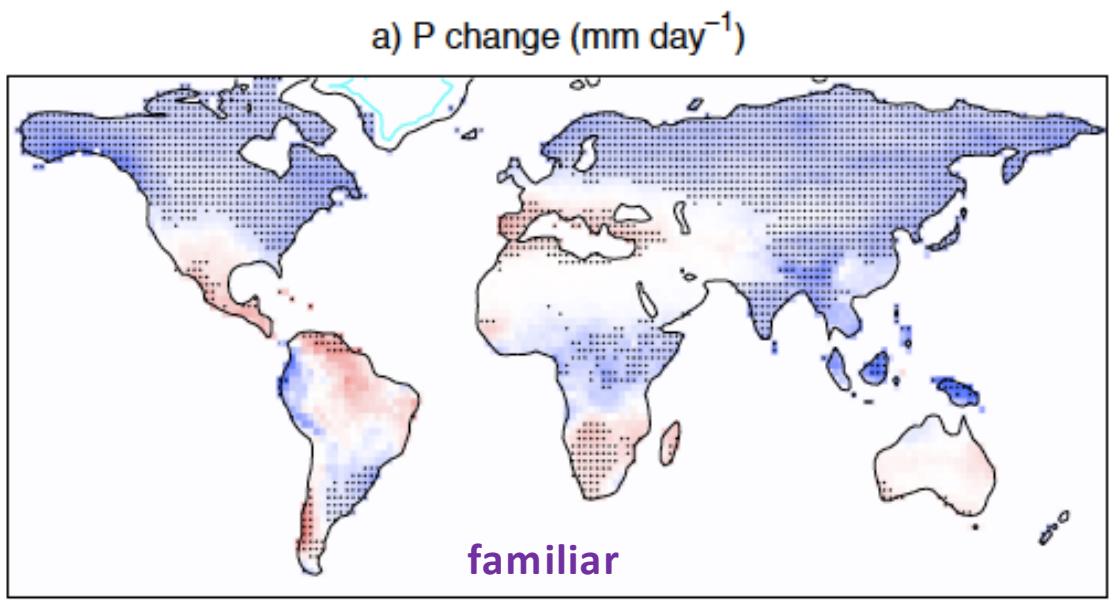

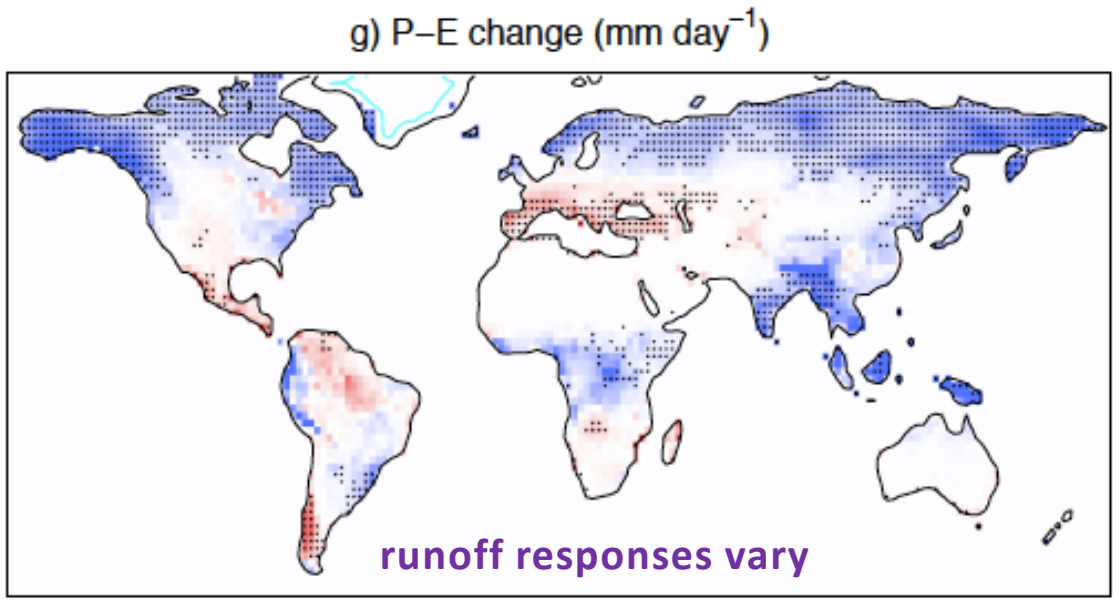

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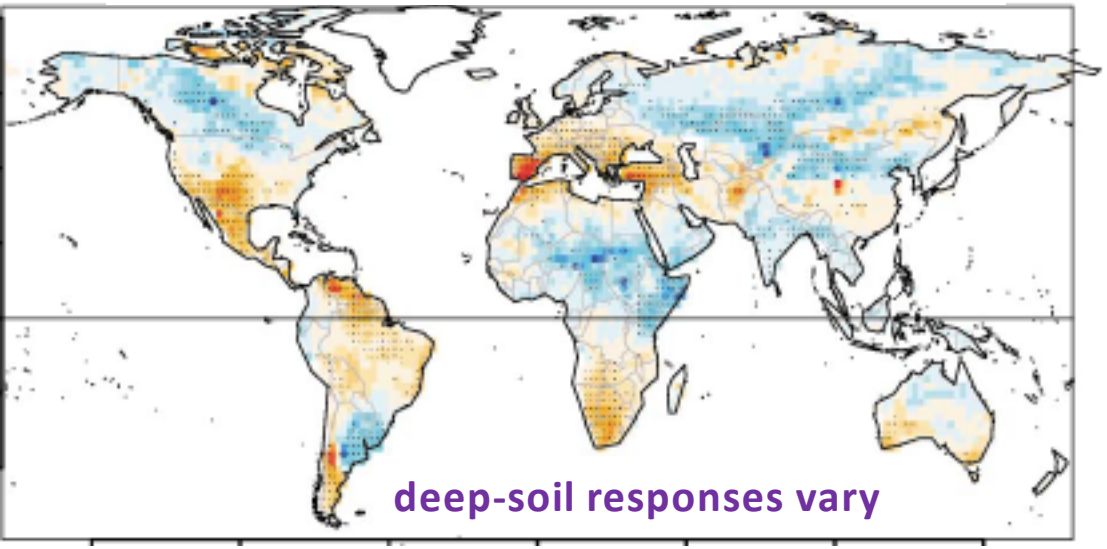

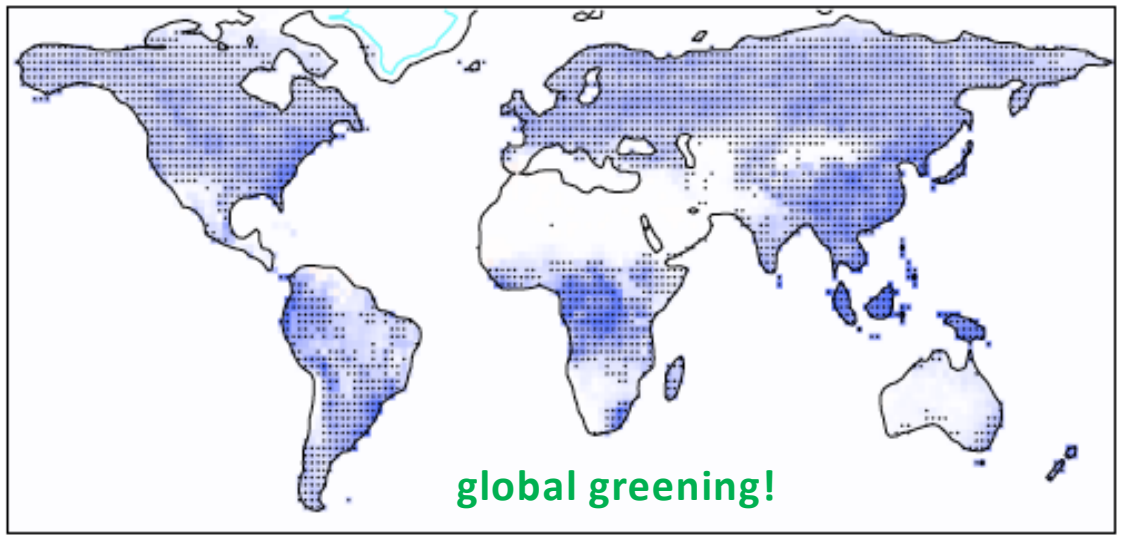

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Highlights

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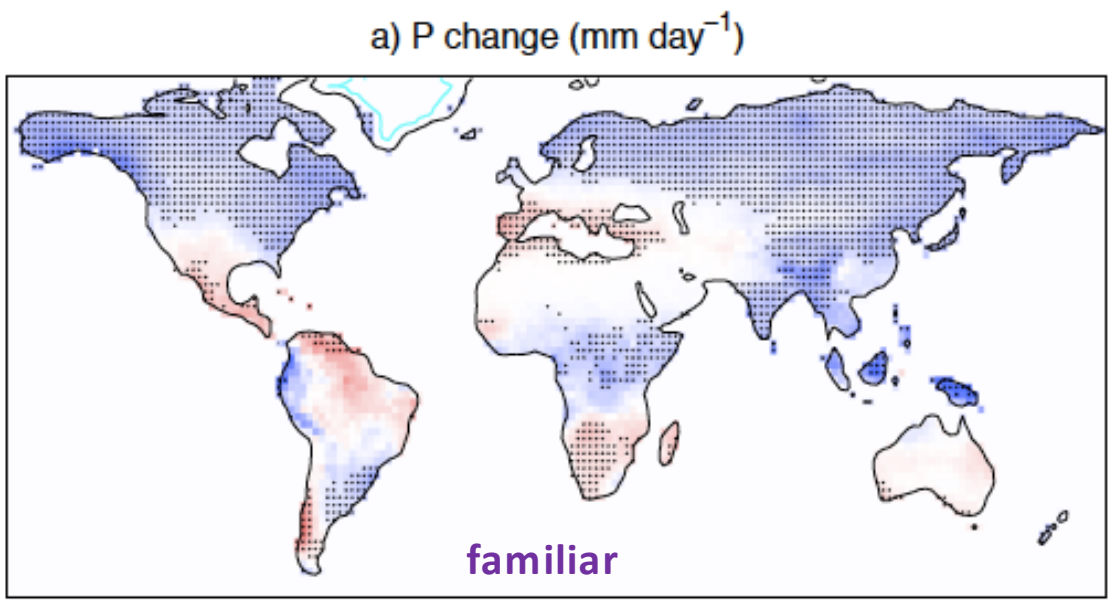

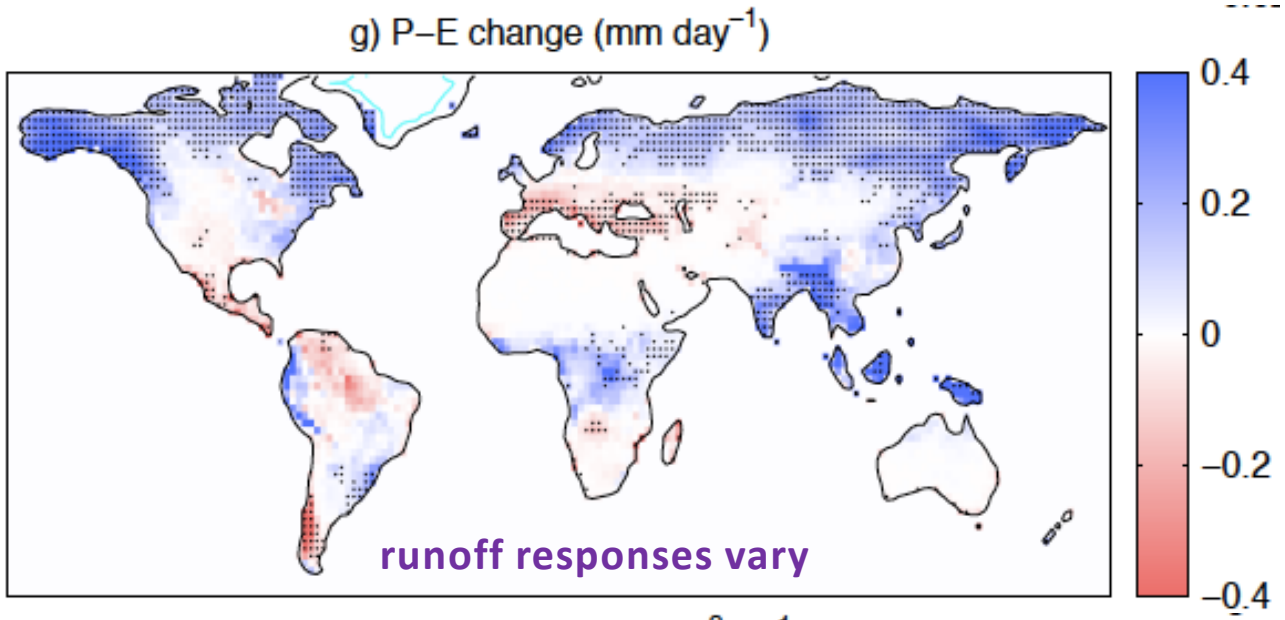

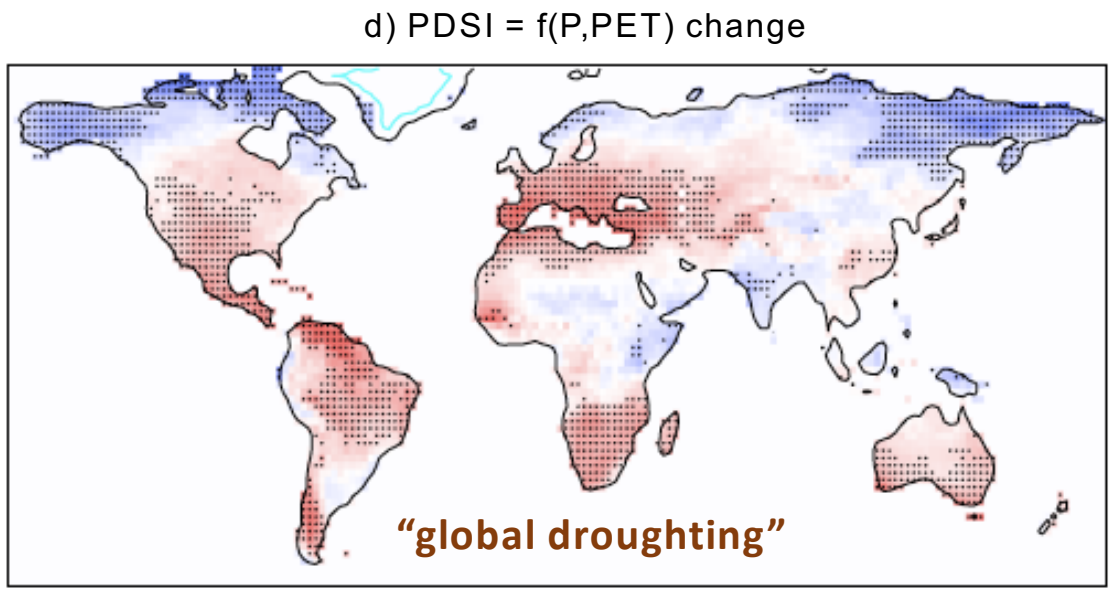

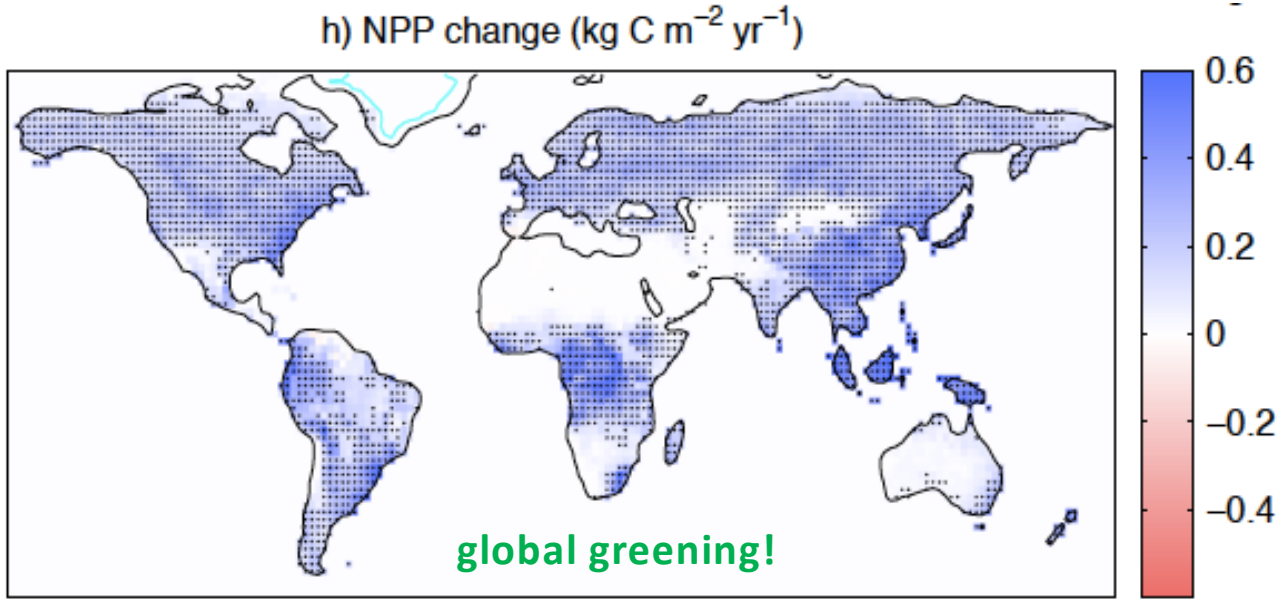

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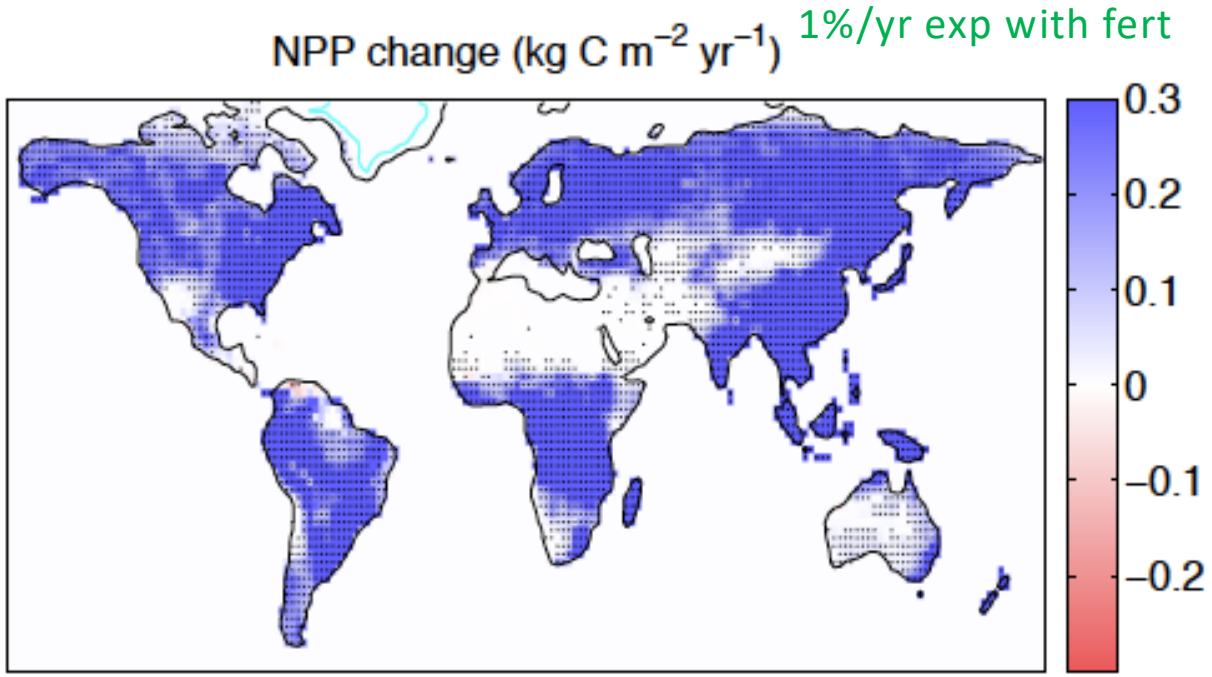

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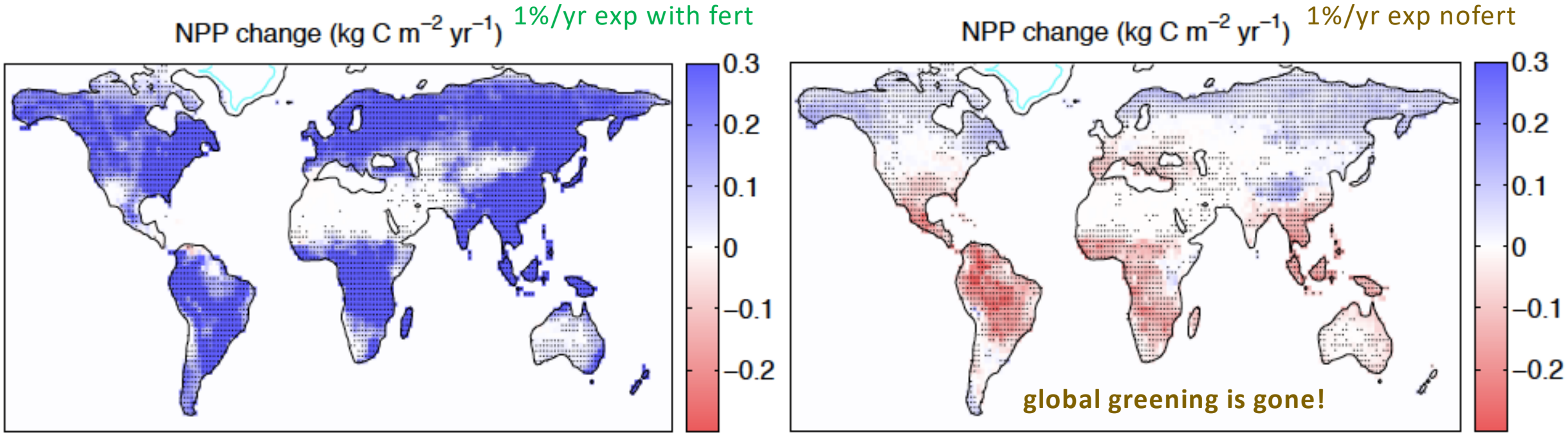

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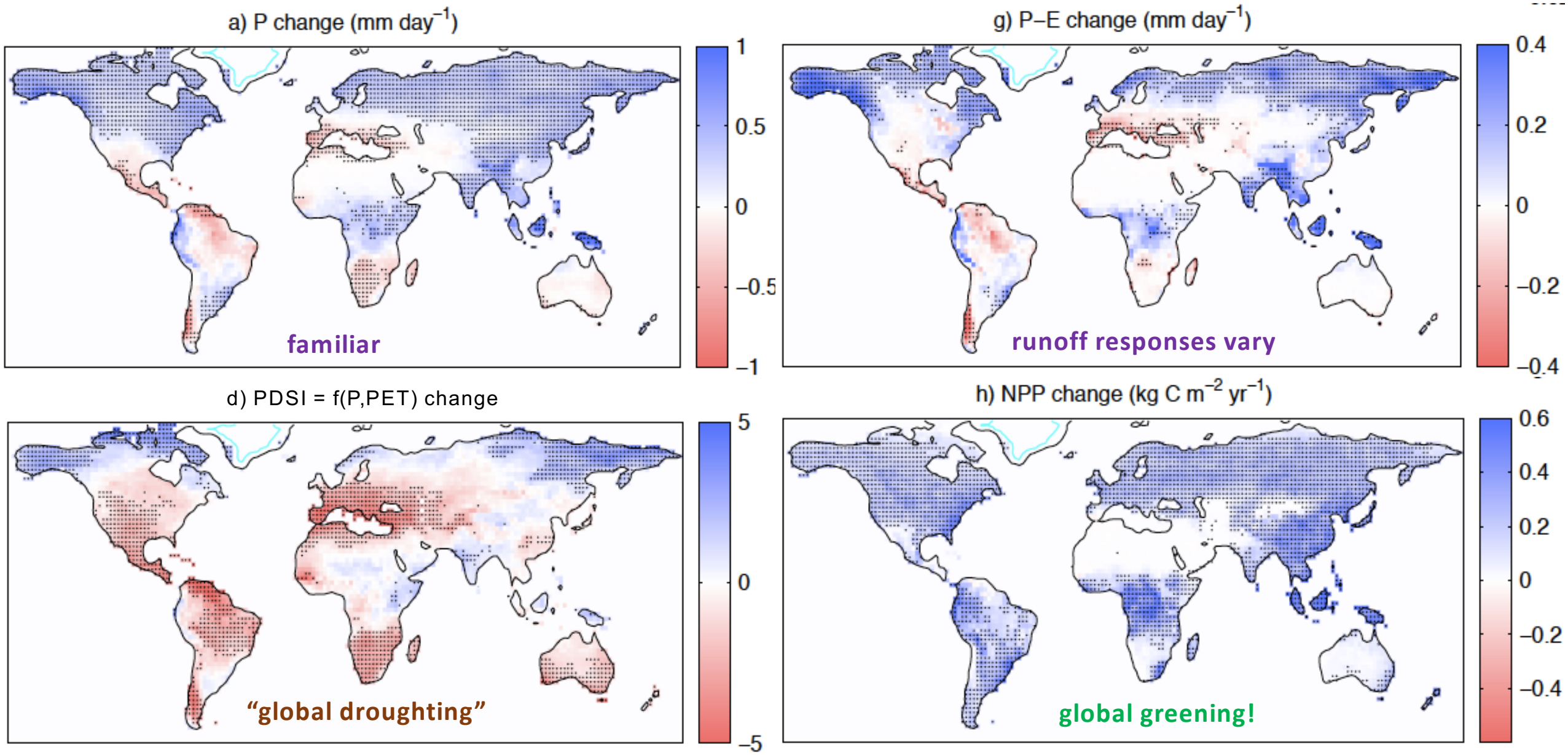
- Could be mix of:
  - stomatal closure (due to CO_2 & VPD increases) -> less E, thus more runoff (many)
  - increased "flashiness" of P -> more direct runoff (Dai)
  - increased seasonality of P (Chou) -> more runoff
  - PET actually doesn't depend on temperature at all? (Milly)

But, in any case, this is what the models do.



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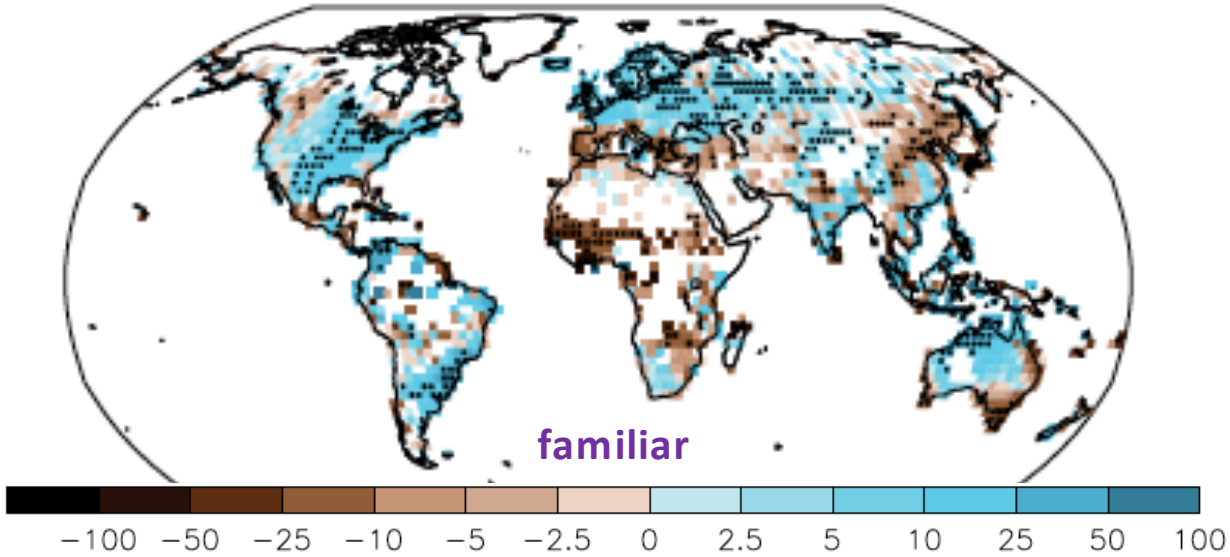
Observed...

1951-2010 P trend (mm/yr per decade; IPCC 2013)



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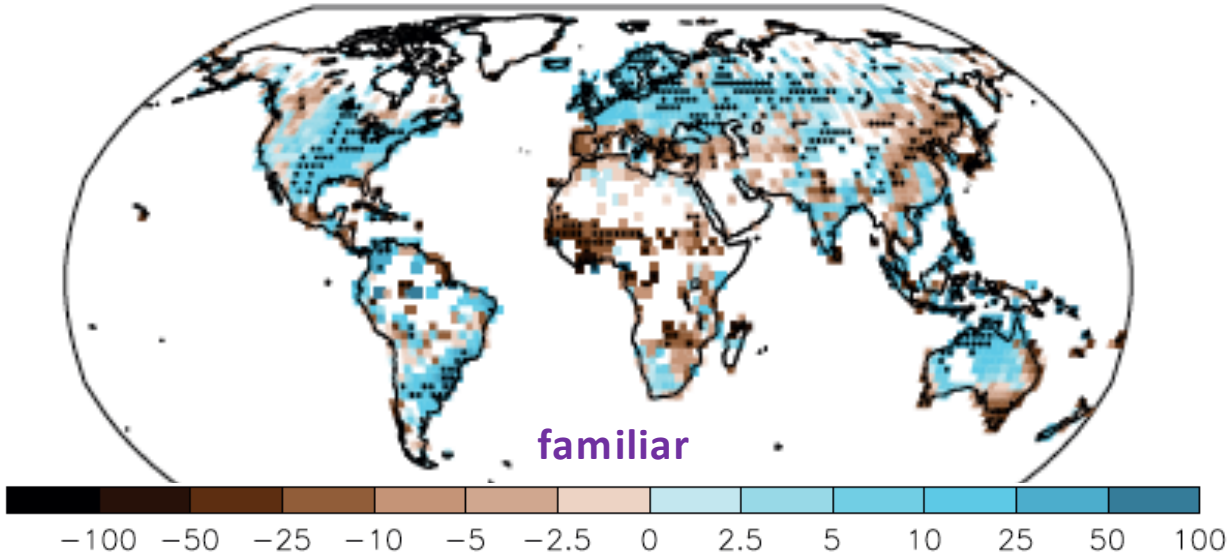

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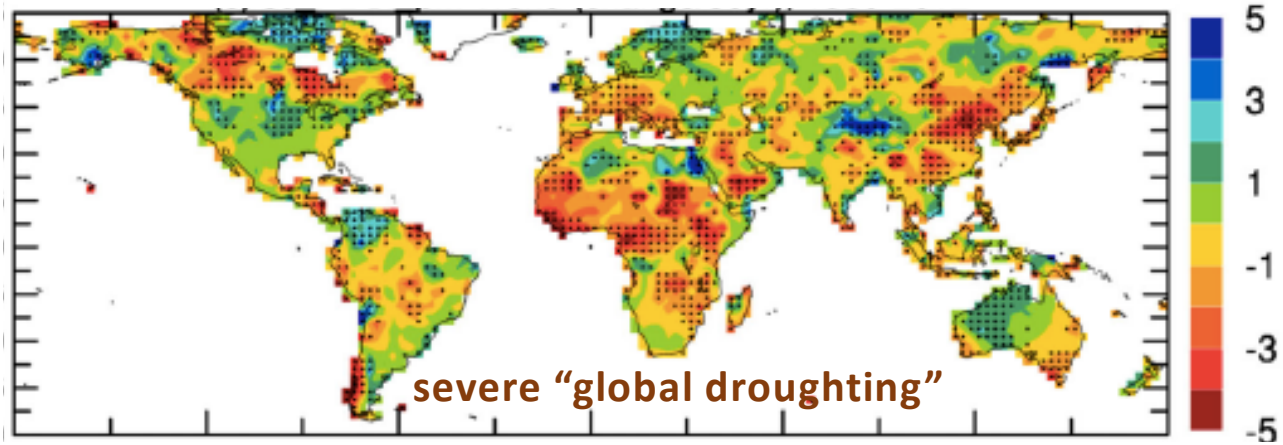

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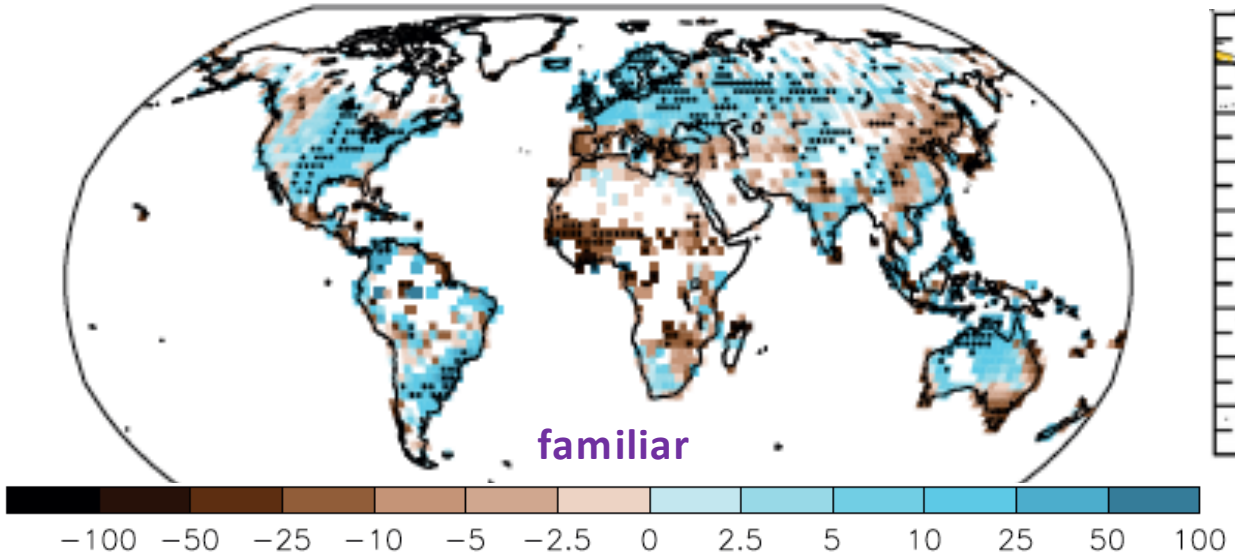

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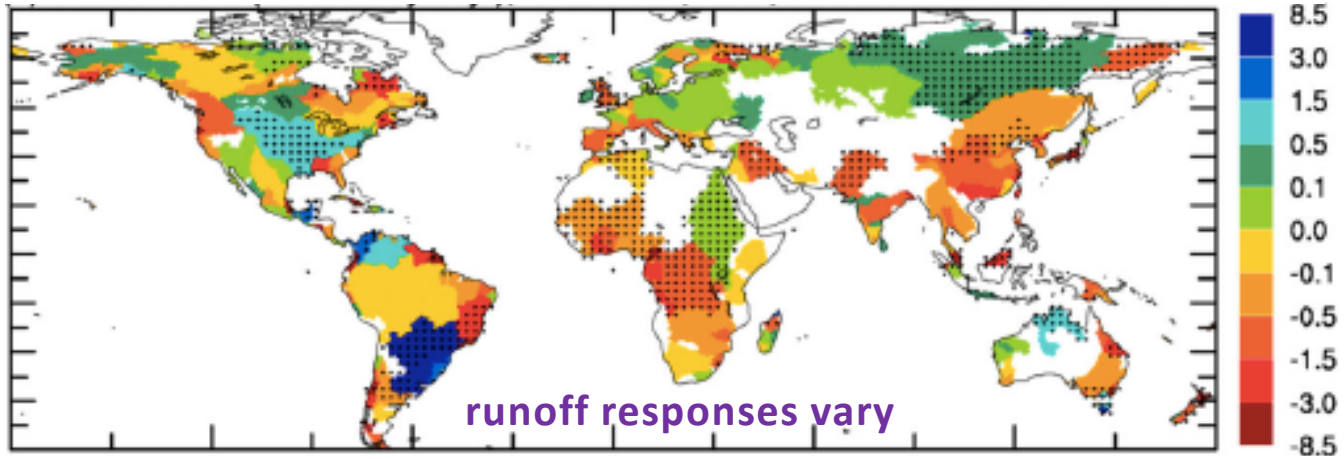

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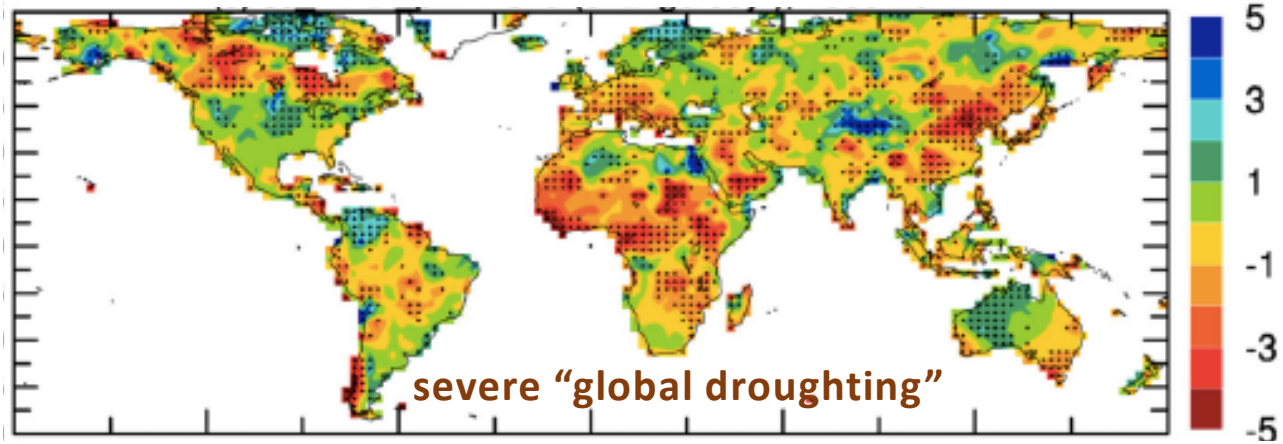

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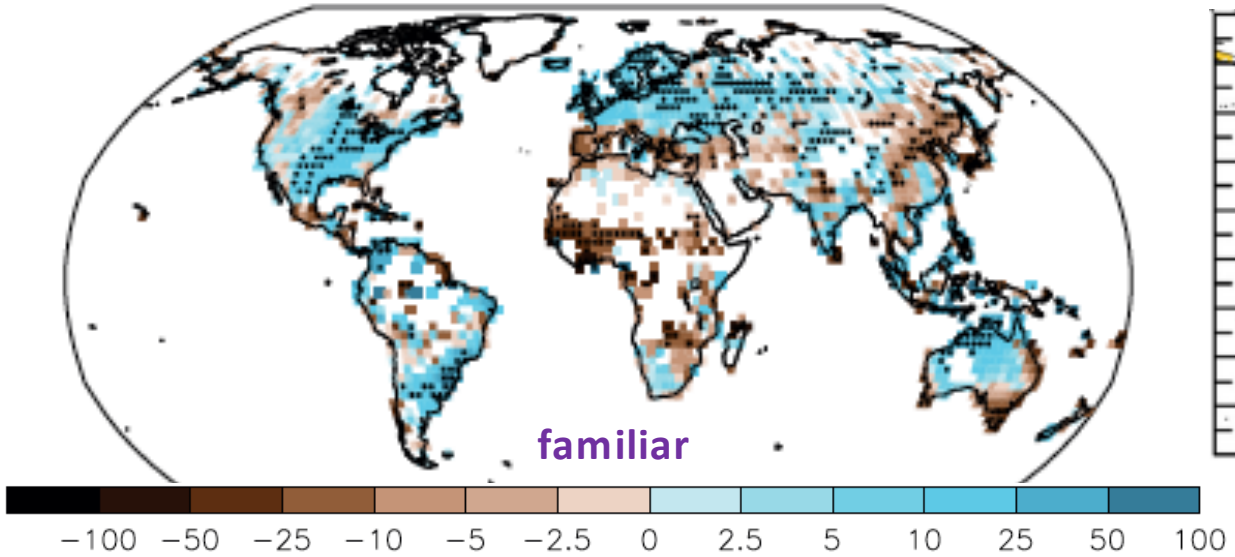

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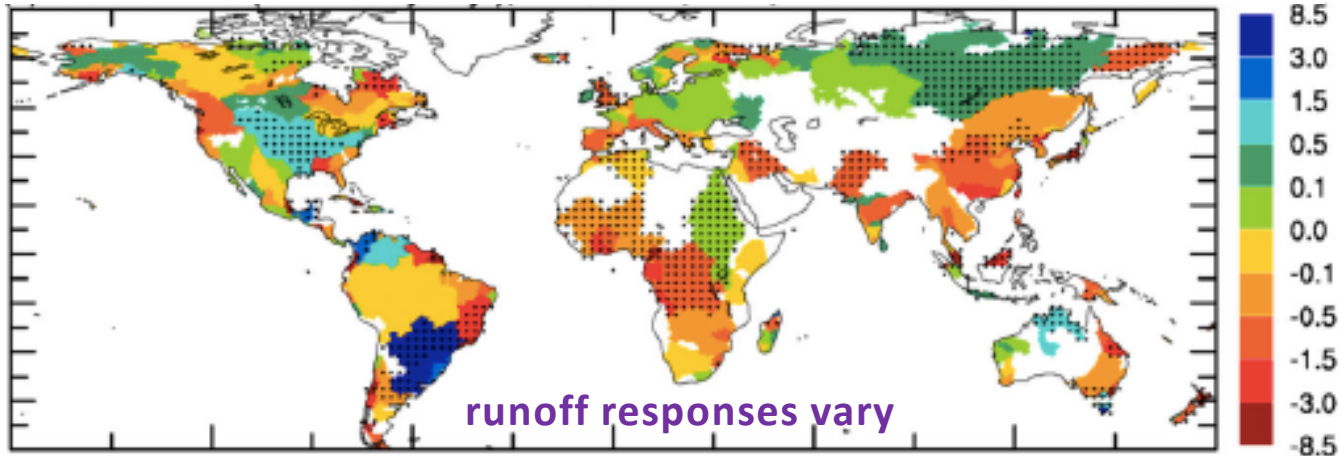

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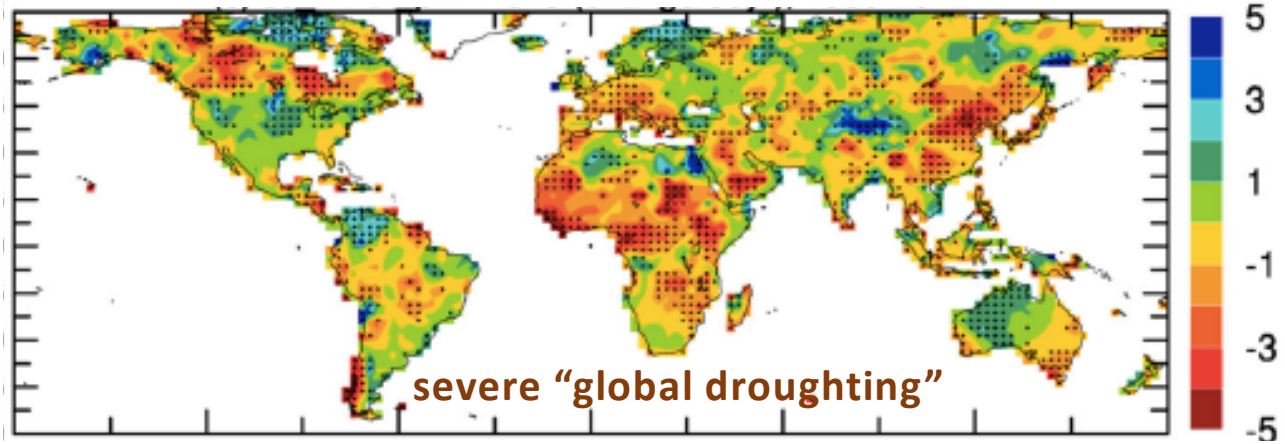
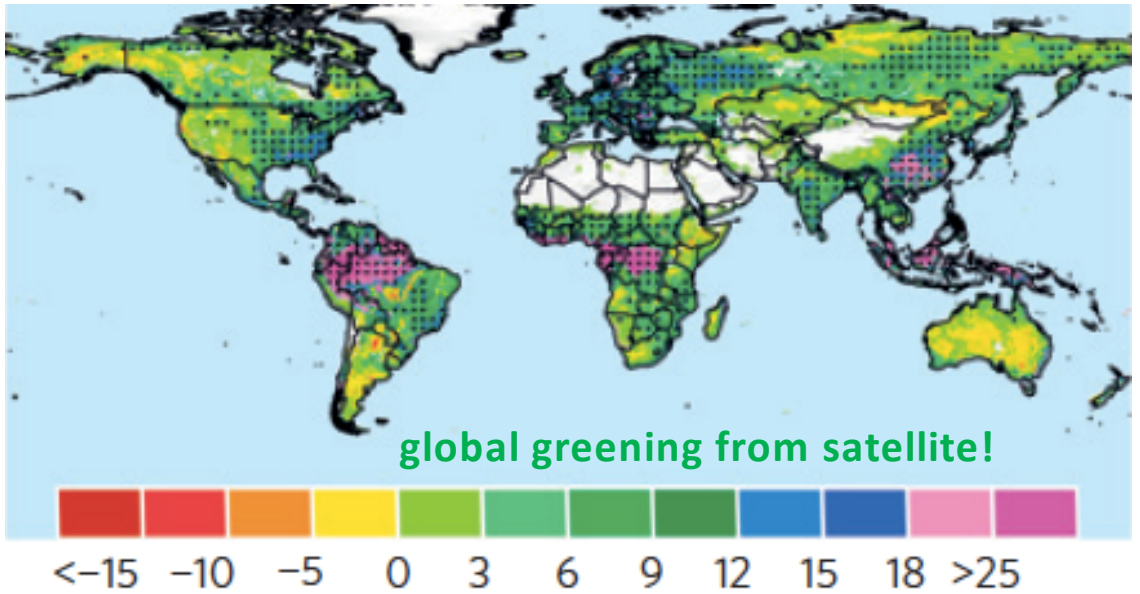


1982-2009 leaf area trend (0.1m2/m2 per decade; Zhu et al 2016)



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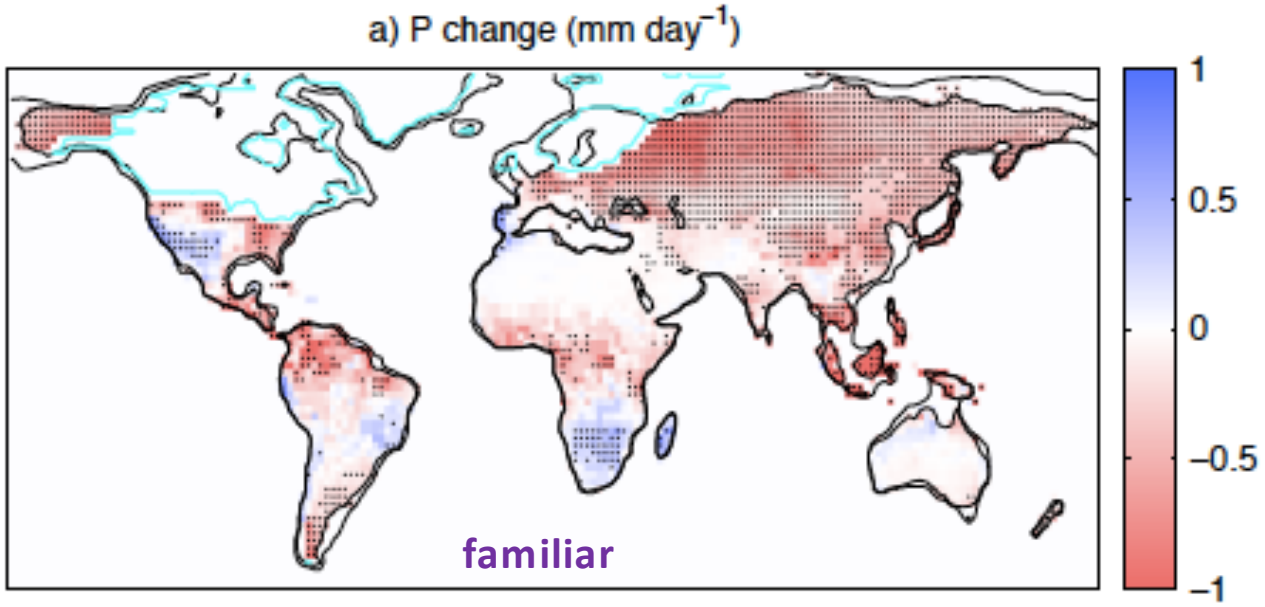
  - I'll actually display it as interglacial-to-glacial cooling & CO_2 drop ("anti-analog")

CMIP5-median LGM minus preindustrial…



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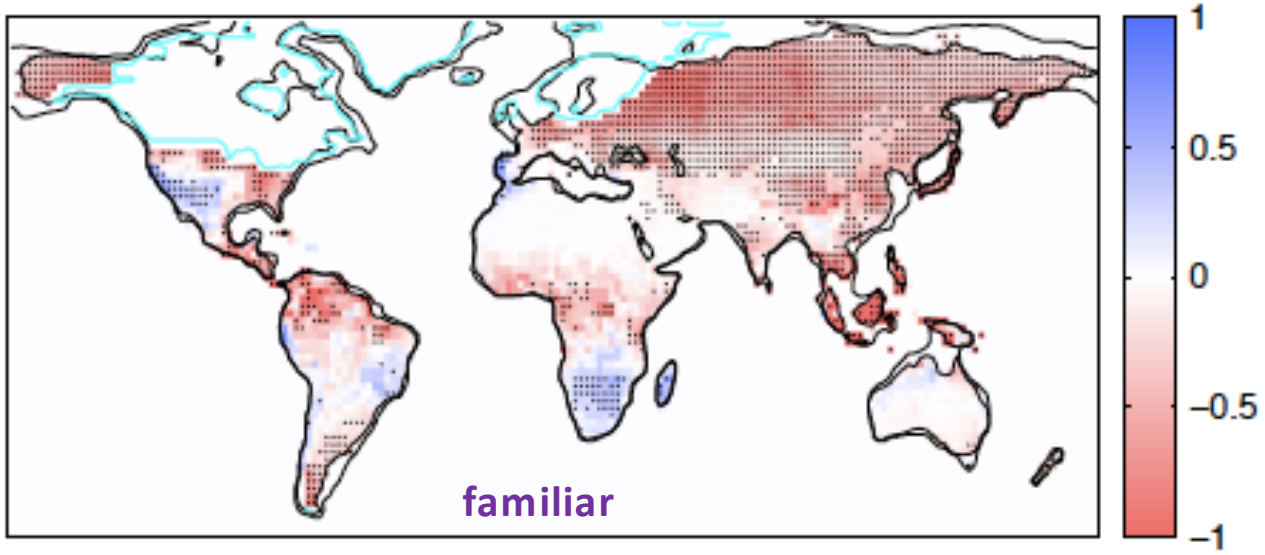
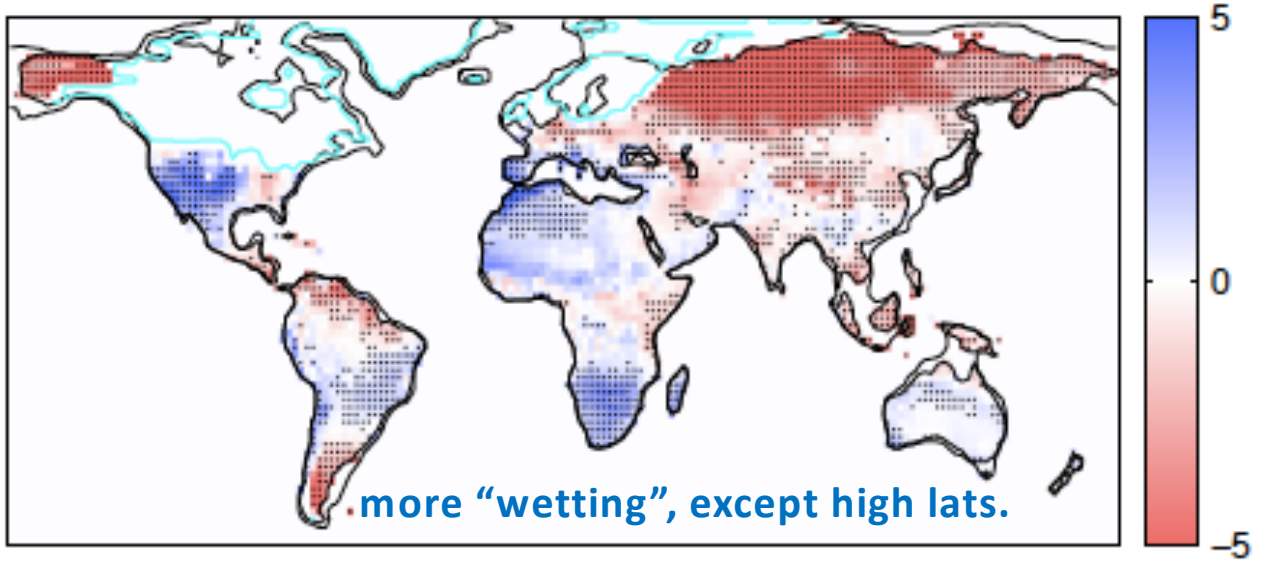


d) PDSI = f(P,PET) change



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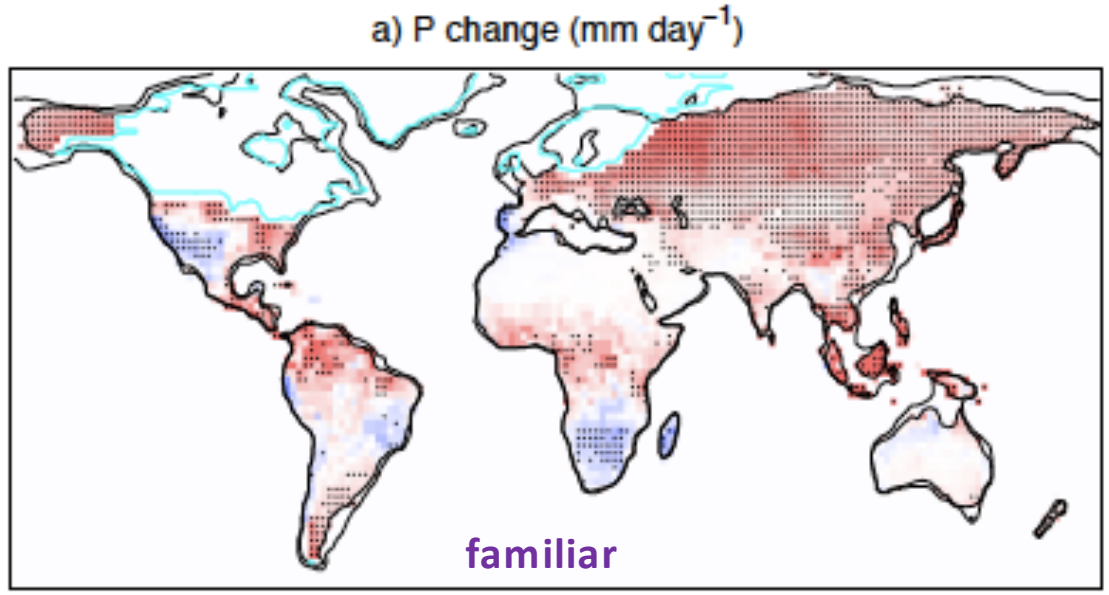

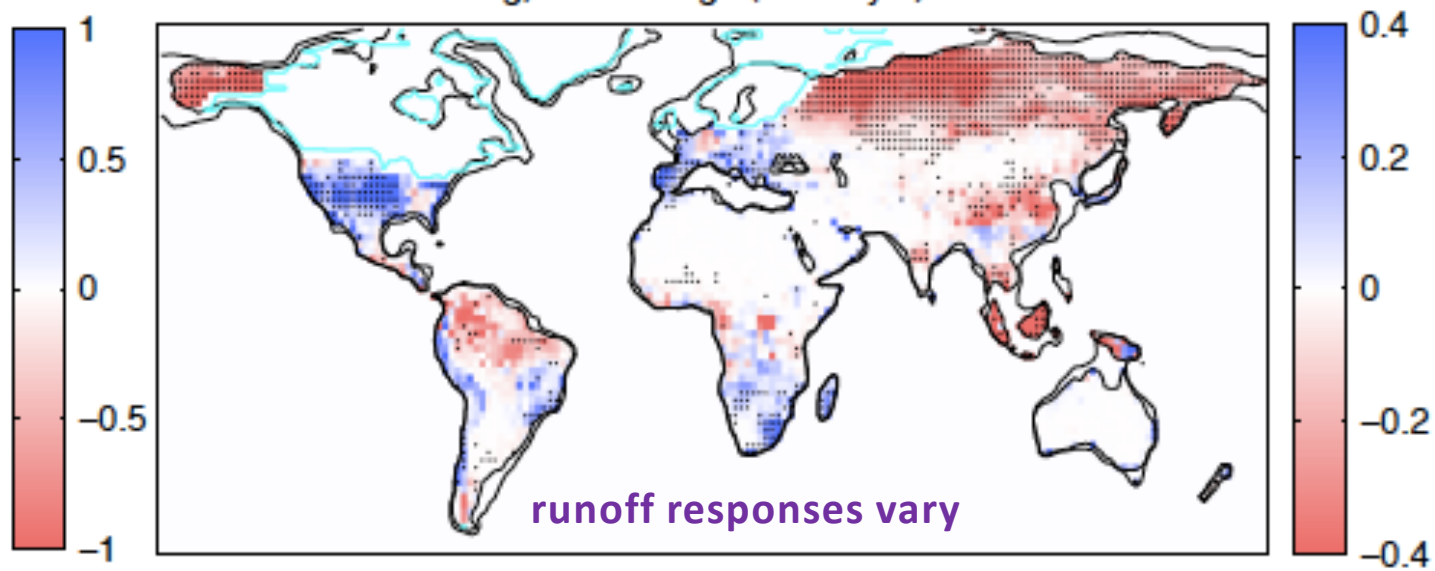

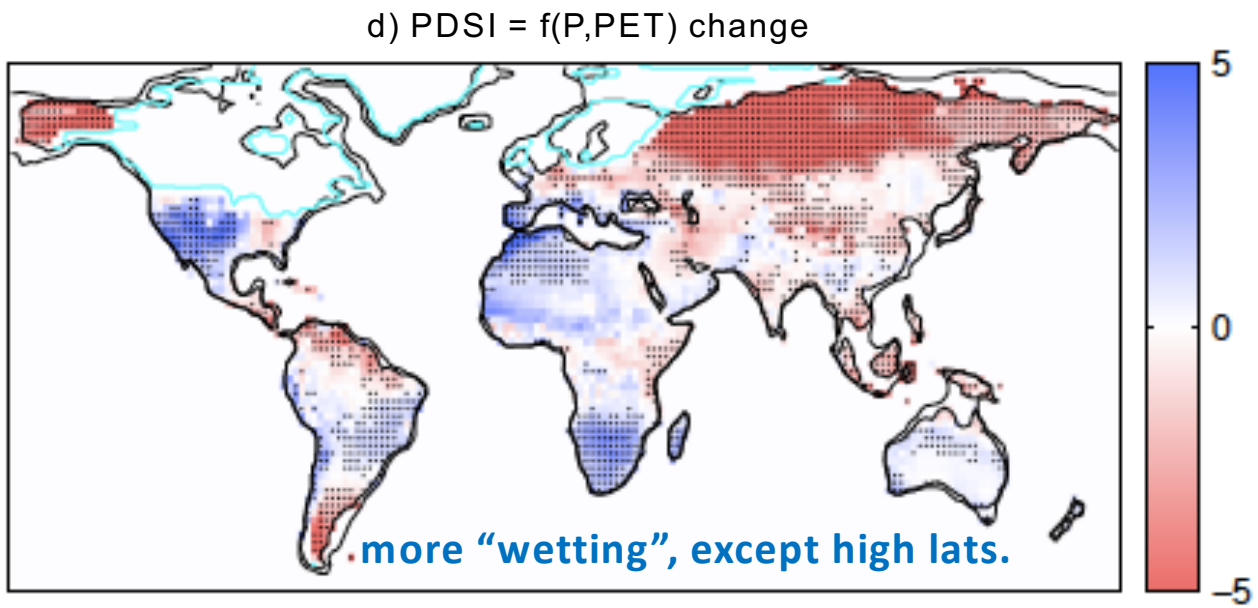

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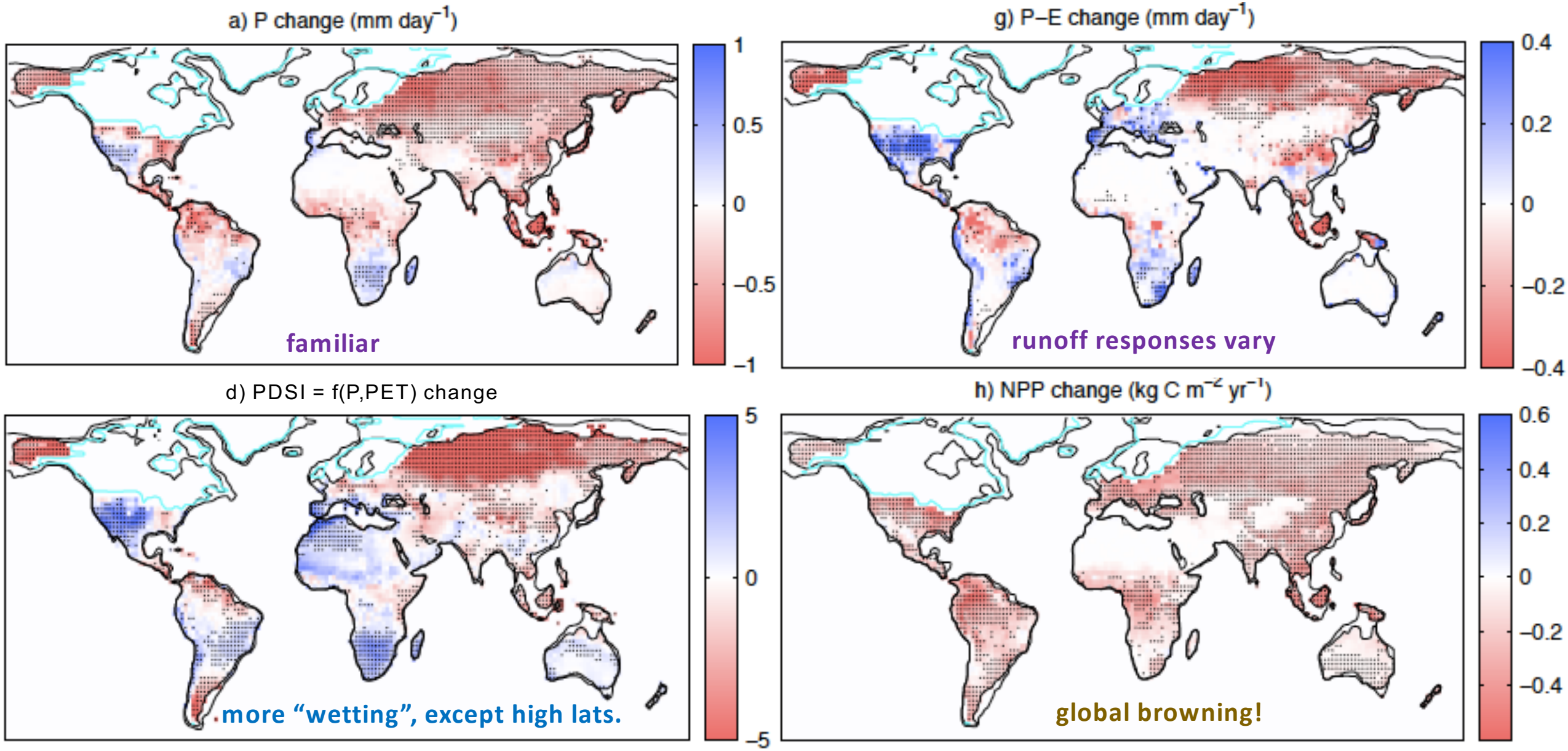

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LGM vegetation was compiled by BIOME6000

Pollen (& macrofossil) data -> "Biomization" statistical approach:
Prentice et al (1996), *Clim. Dyn.*, methods
Elenga et al (2000), *J. Biogeogr.,* Africa & W. Europe
Takahara et al (2000), *J. Biogeogr.,* Japan
Tarasov et al (2000), *J. Biogeogr.,* Former Soviet & Mongolia
Thompson and Anderson (2000), *J. Biogeogr.*, Western US
Williams et al (2000), *J. Biogeogr.*, Eastern US
Yu et al (2000), *J. Biogeogr.*, China
Harrison et al (2001), *Nature*, more China
Bigelow et al (2003), *JGR*, pan-Arctic (>55N)
Pickett et al (2004), *J. Biogeogr.,* Australia to SE Asia
Marchant et al (2009), *Clim. Past*, Latin America
Mostly downloadable in Excel format

-Hundreds of sites – determined present potential vegetation for each
-(Tables S1-S10 in 2017 J. Clim. paper)

On following maps:

- (o) : LGM vegetation more open, “drier-looking” than PI.

PI rainforest -> LGM seasonal forest, PI forest -> LGM grassland, etc.

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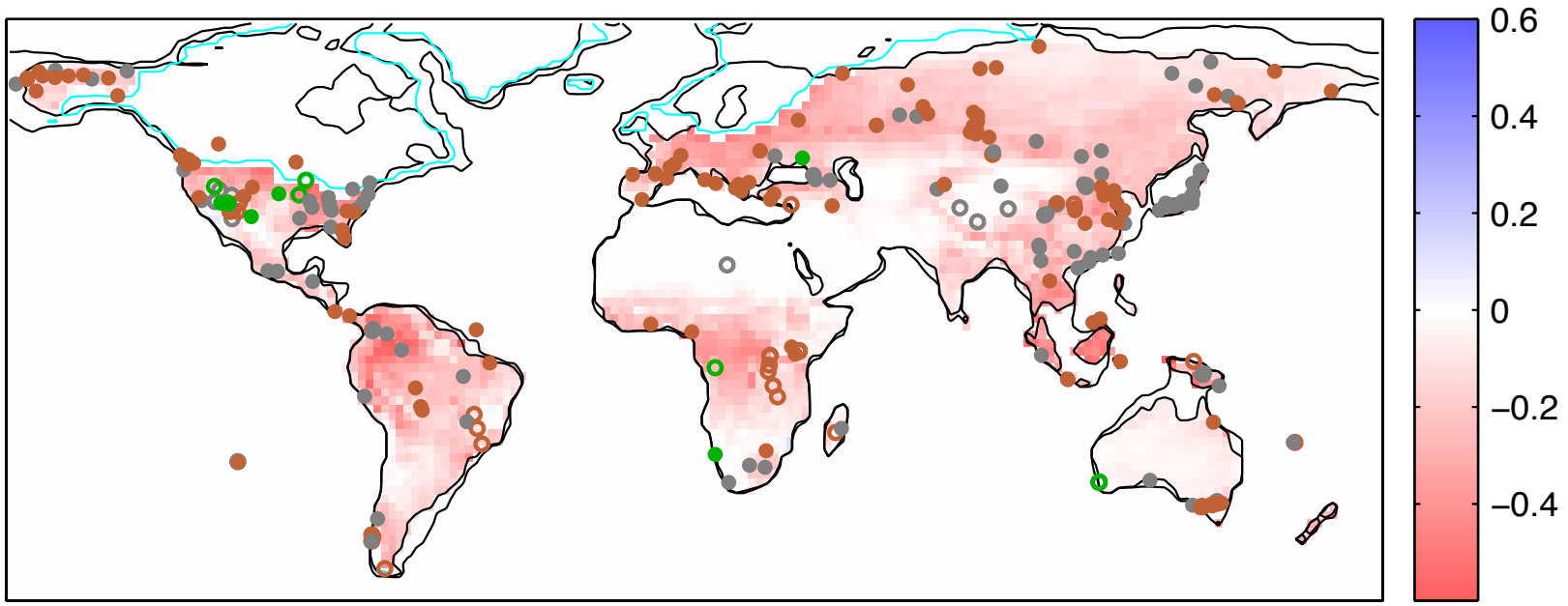
- (○): PI vegetation looks ~as “wet”/”dry” as LGM.

b) NPP change (kg C m^{-2} yr^{-1}) with obs vegetation change



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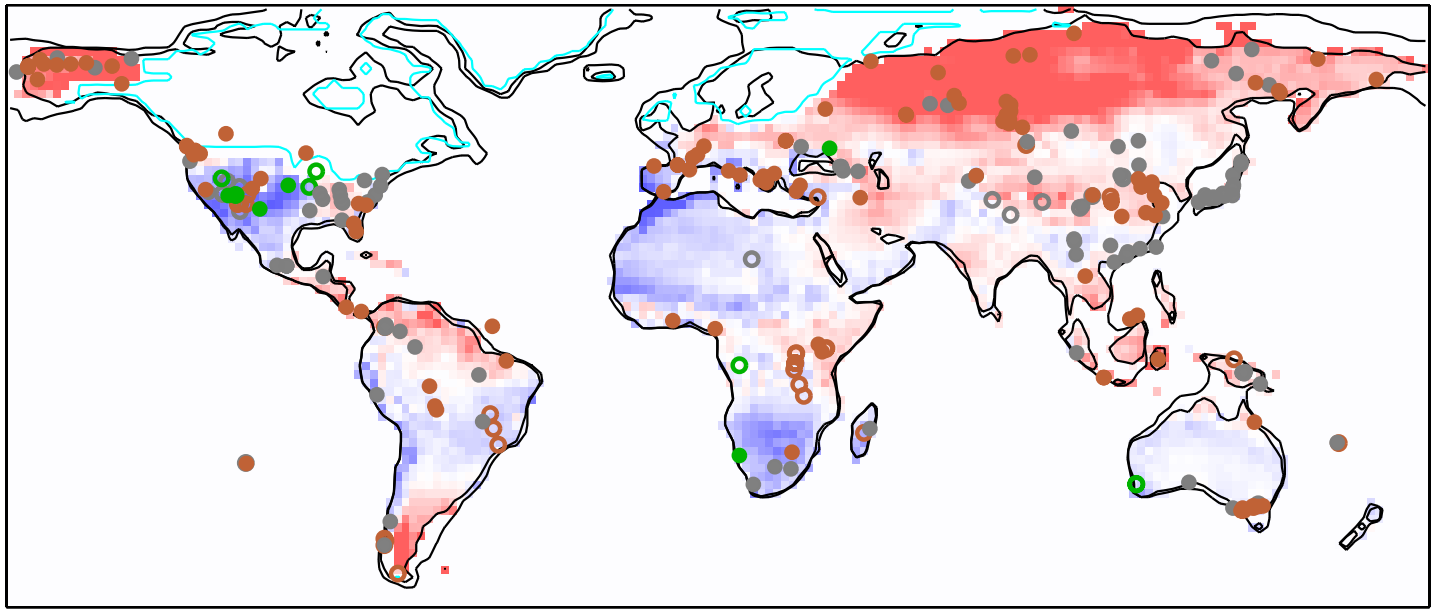
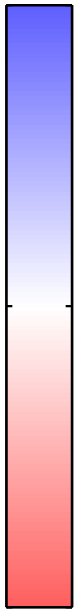
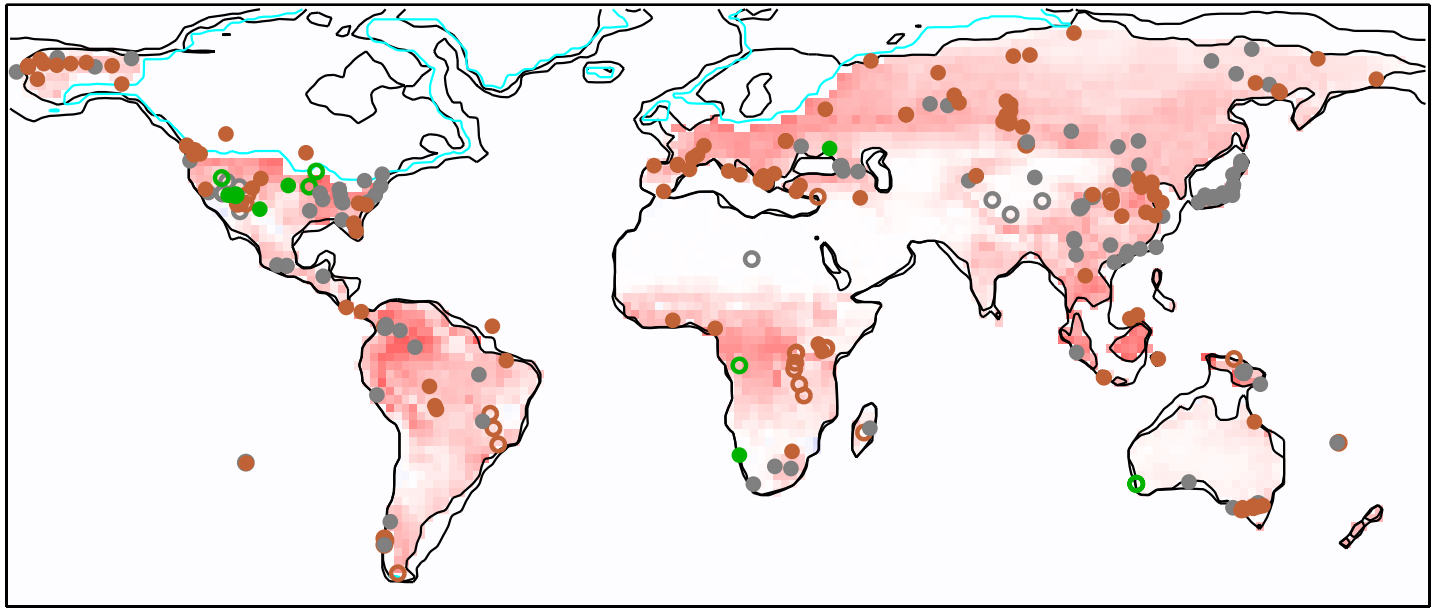
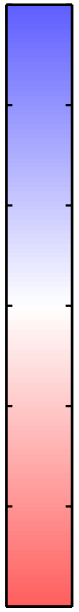




b) NPP change (kg C m^{-2} yr^{-1}) with obs vegetation change





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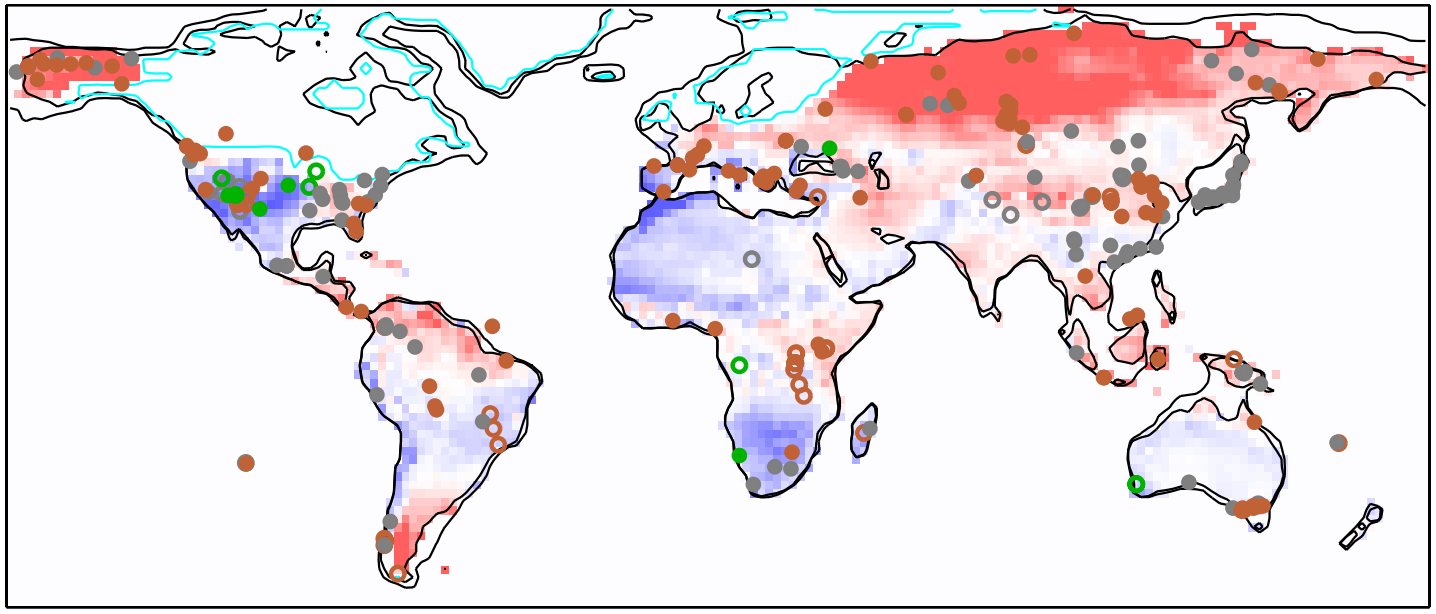

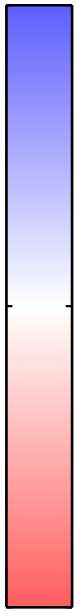

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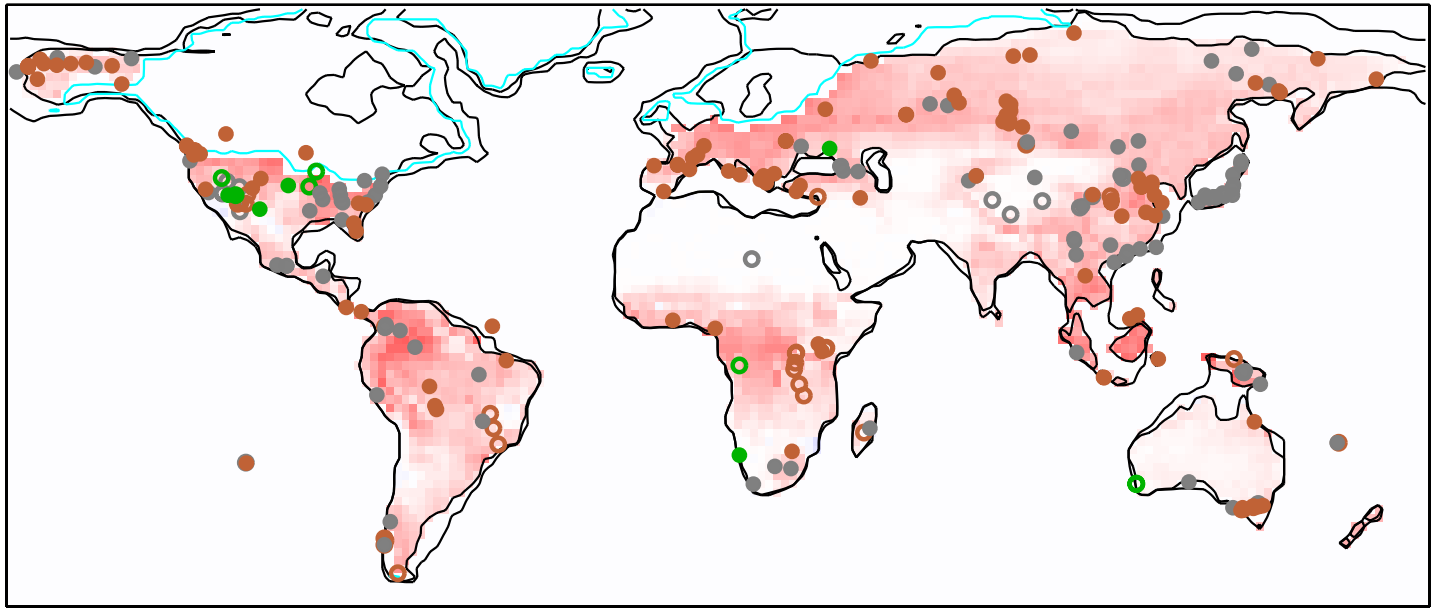

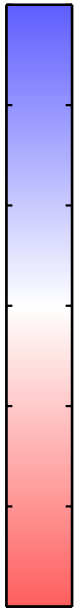

Near-global browning at LGM, despite "less droughty conditions" but in line with model browning

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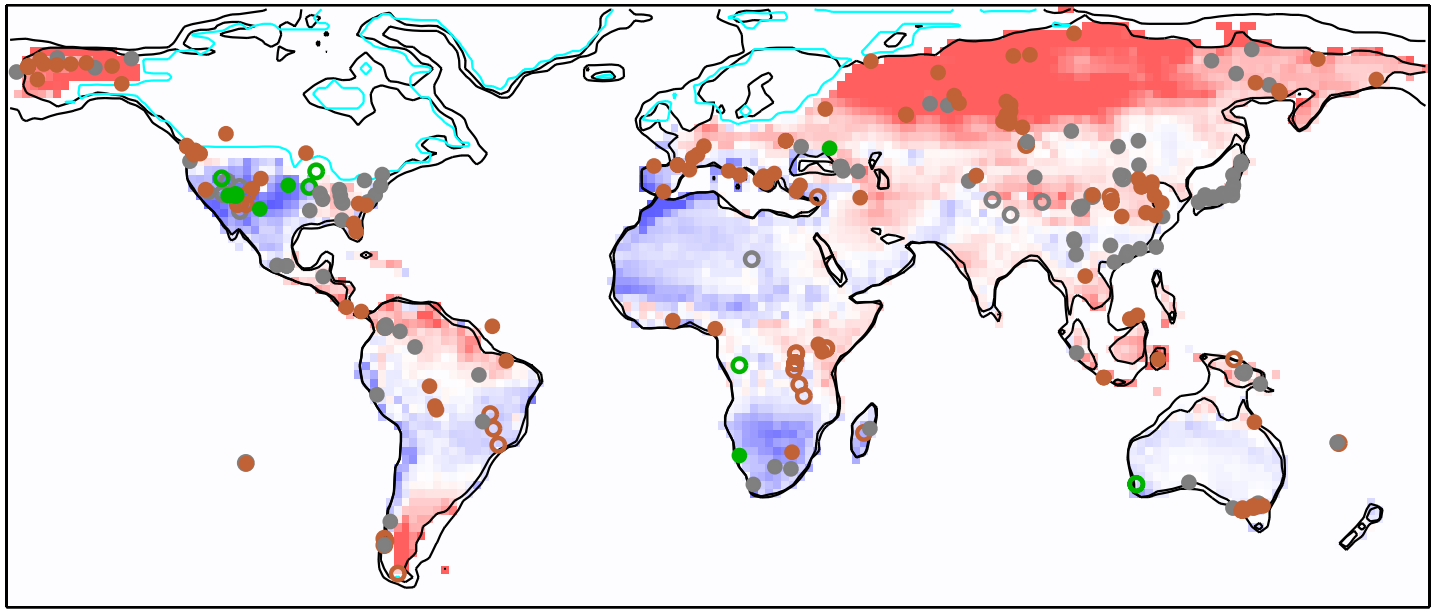

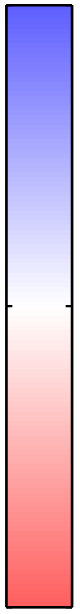

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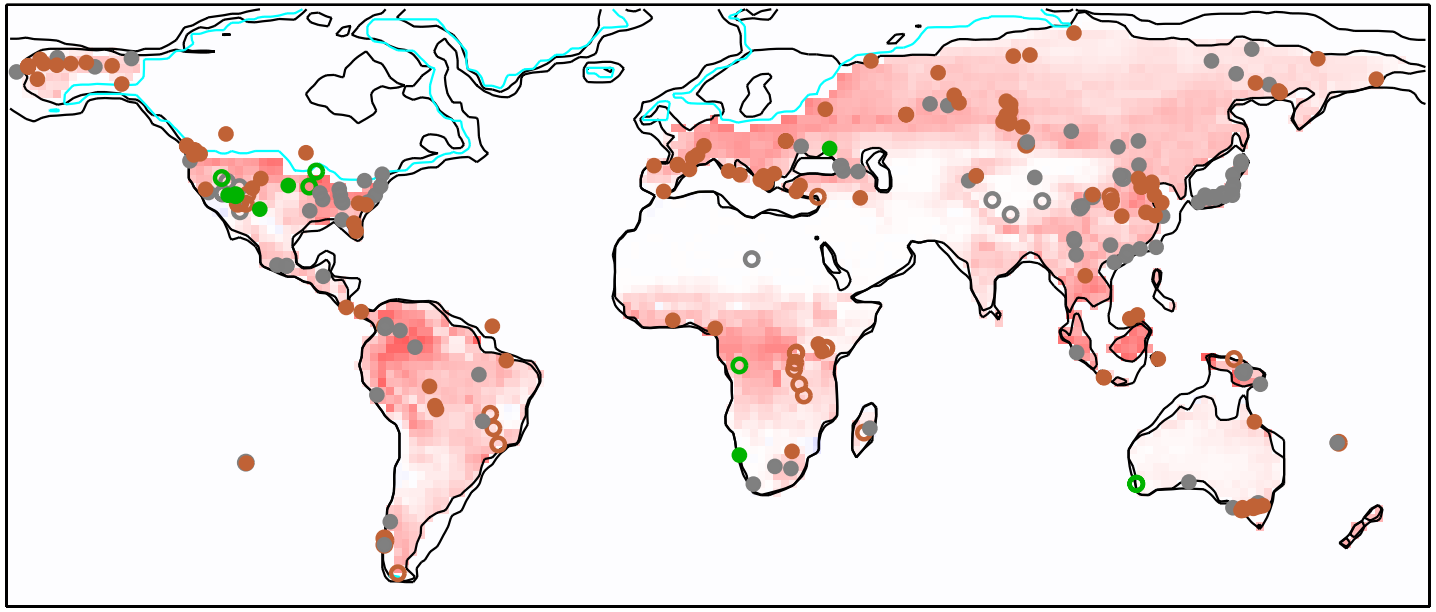
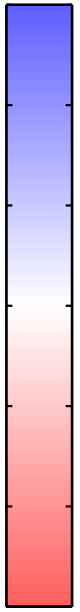
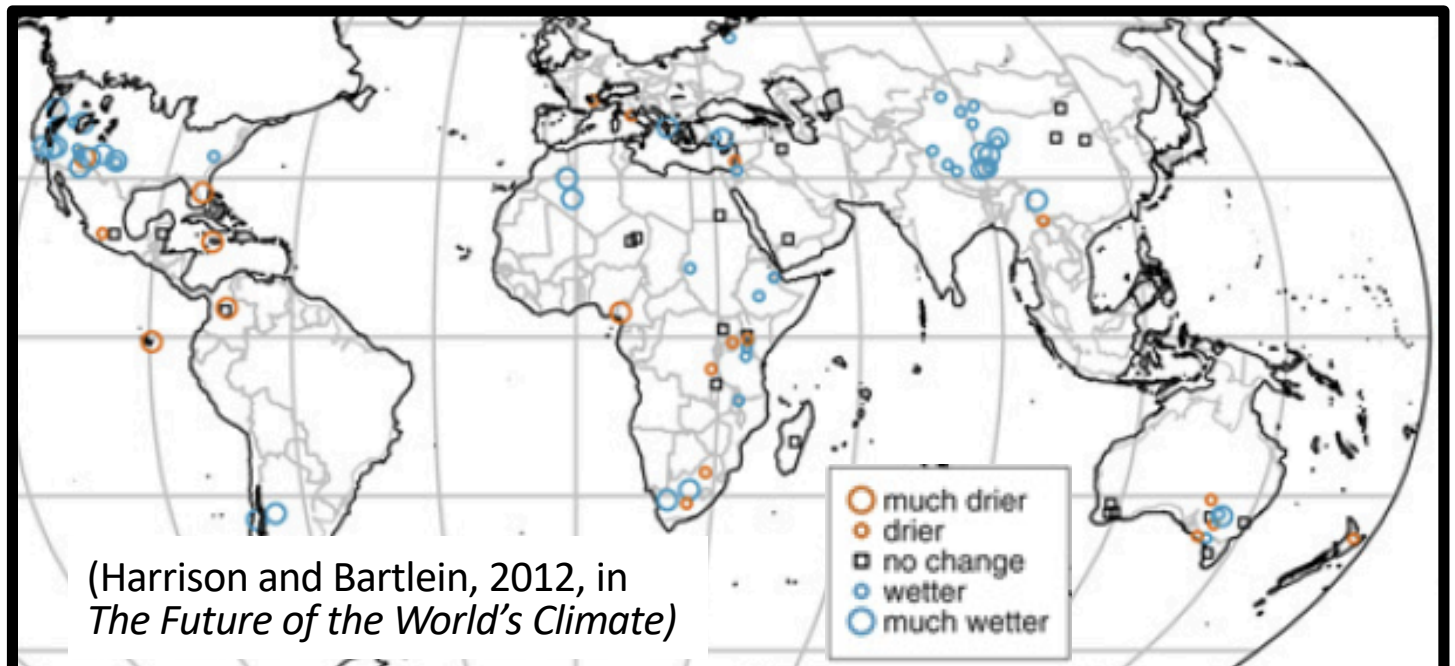




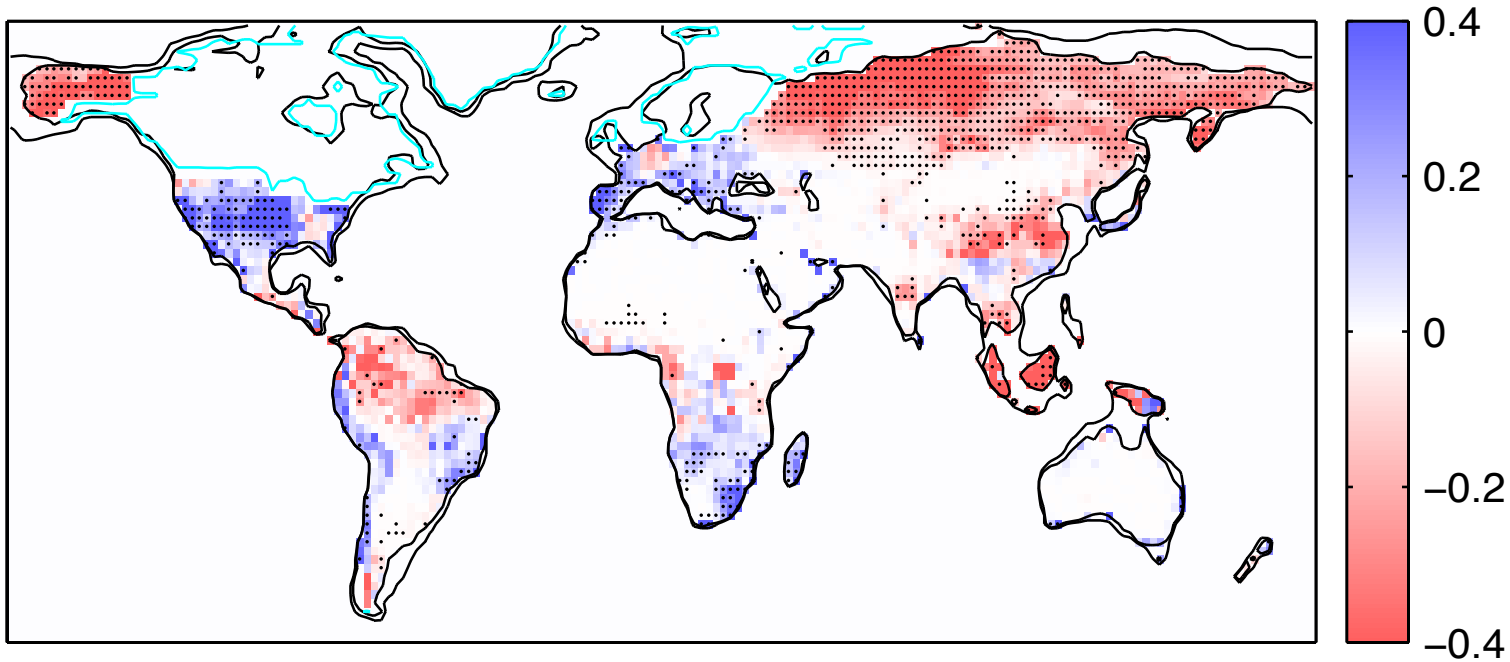
(i.e. near-global greening with warming, despite "drought" but in line with model greening)

Global Lake Status Data Base (direct LGM runoff proxies)



(Harrison and Bartlein, 2012, in *The Future of the World's Climate)*

g) P–E change (mm day^{-1})



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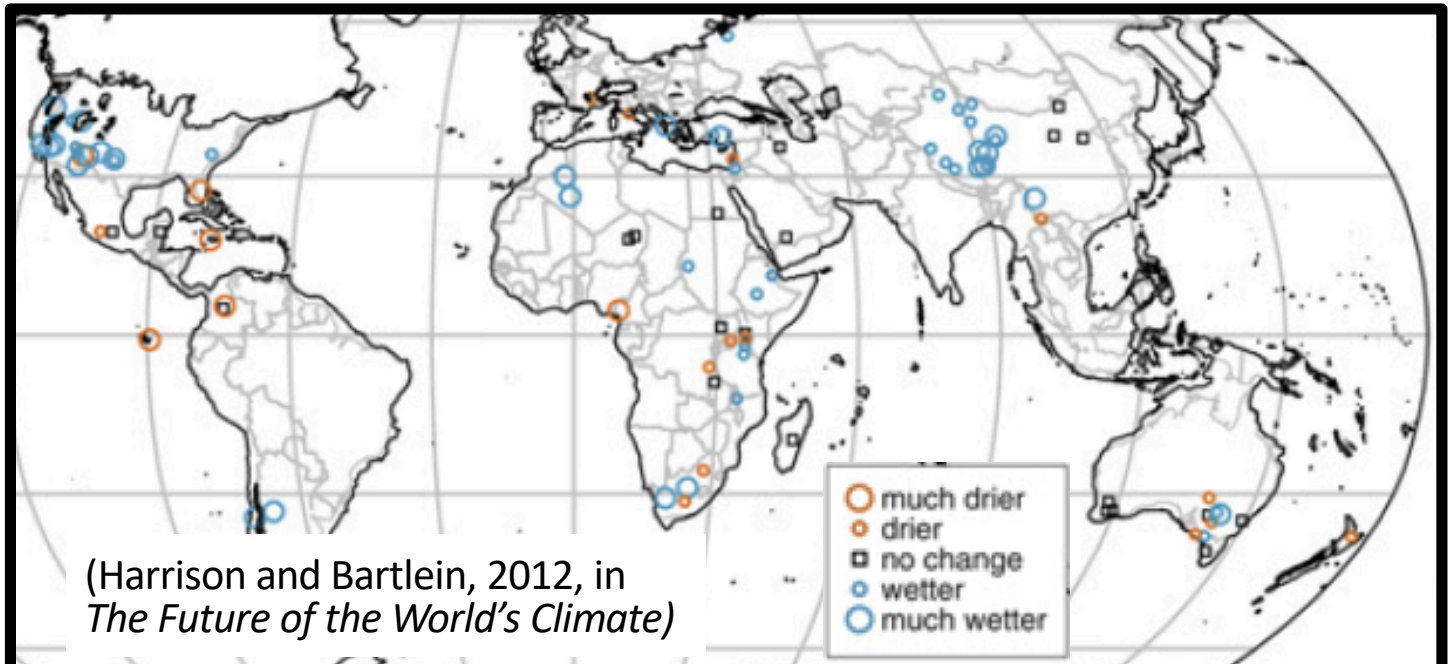

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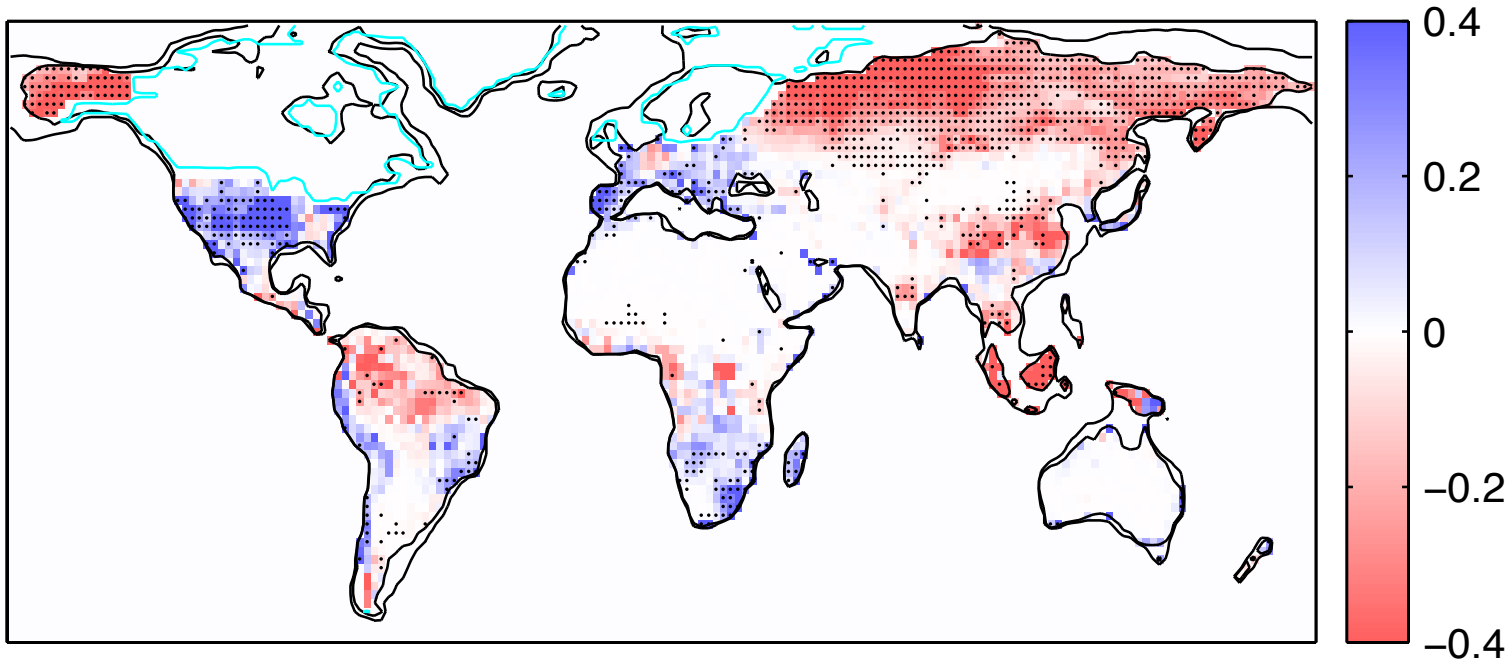

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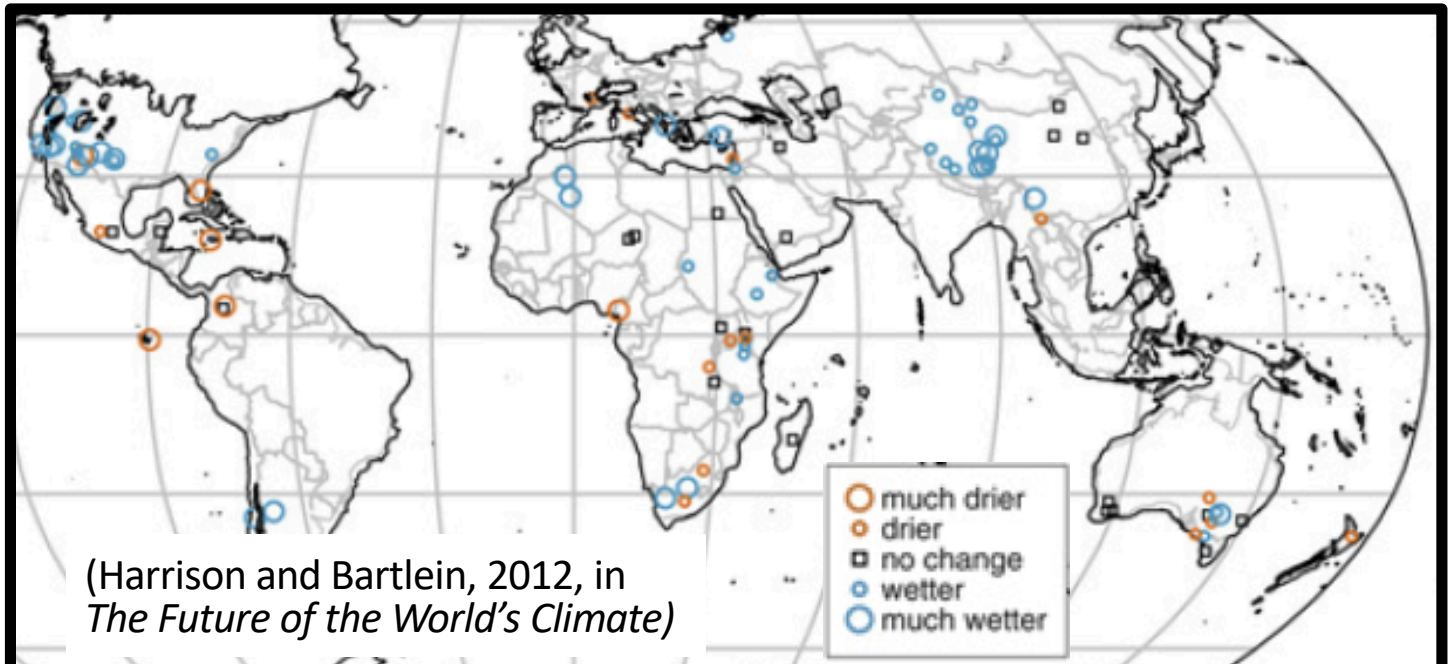

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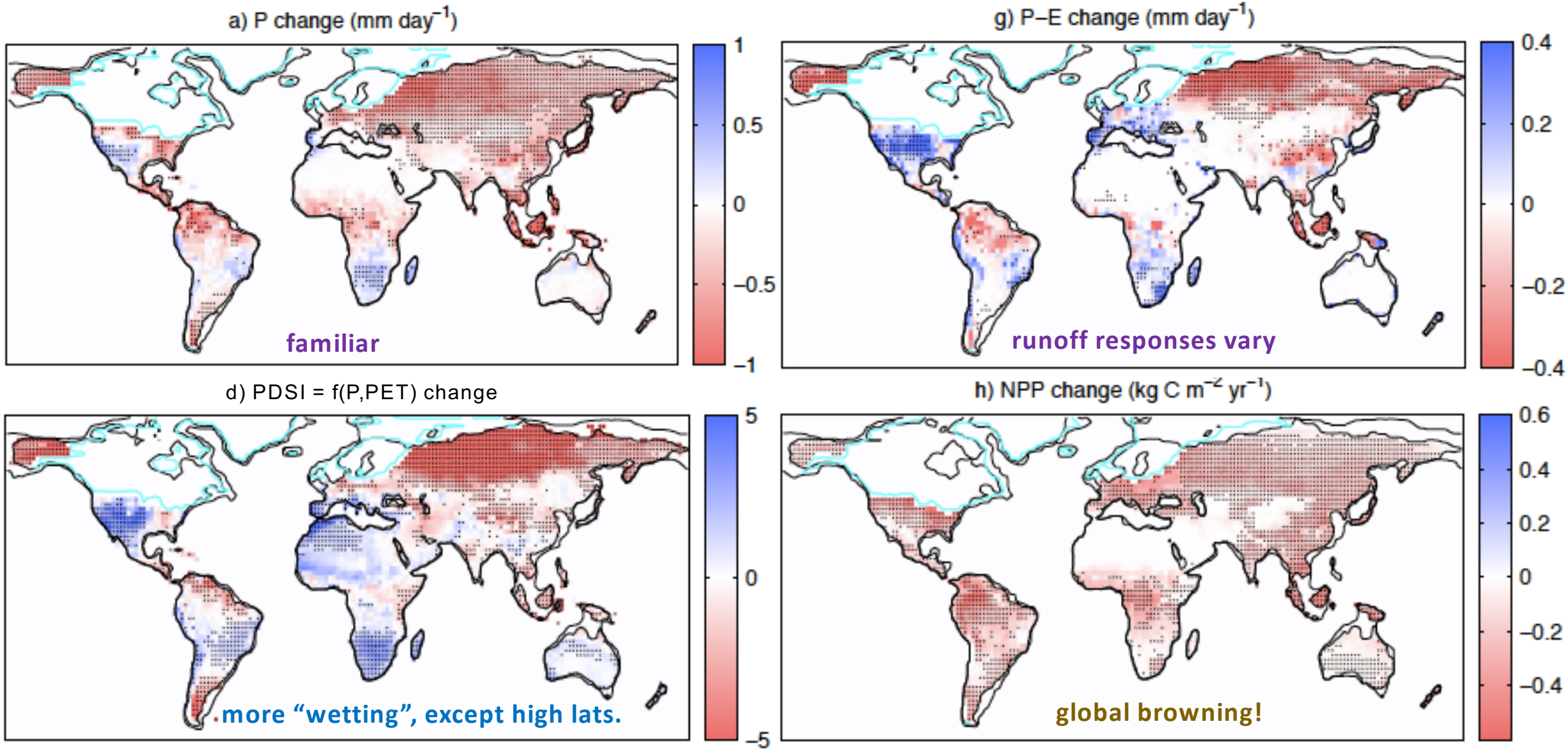
real LGM runoff changes resembled model runoff projections (varied), not vegetation (browning)

CMIP5-median LGM minus preindustrial…



(Stippling = at least 80% of models agree on sign)

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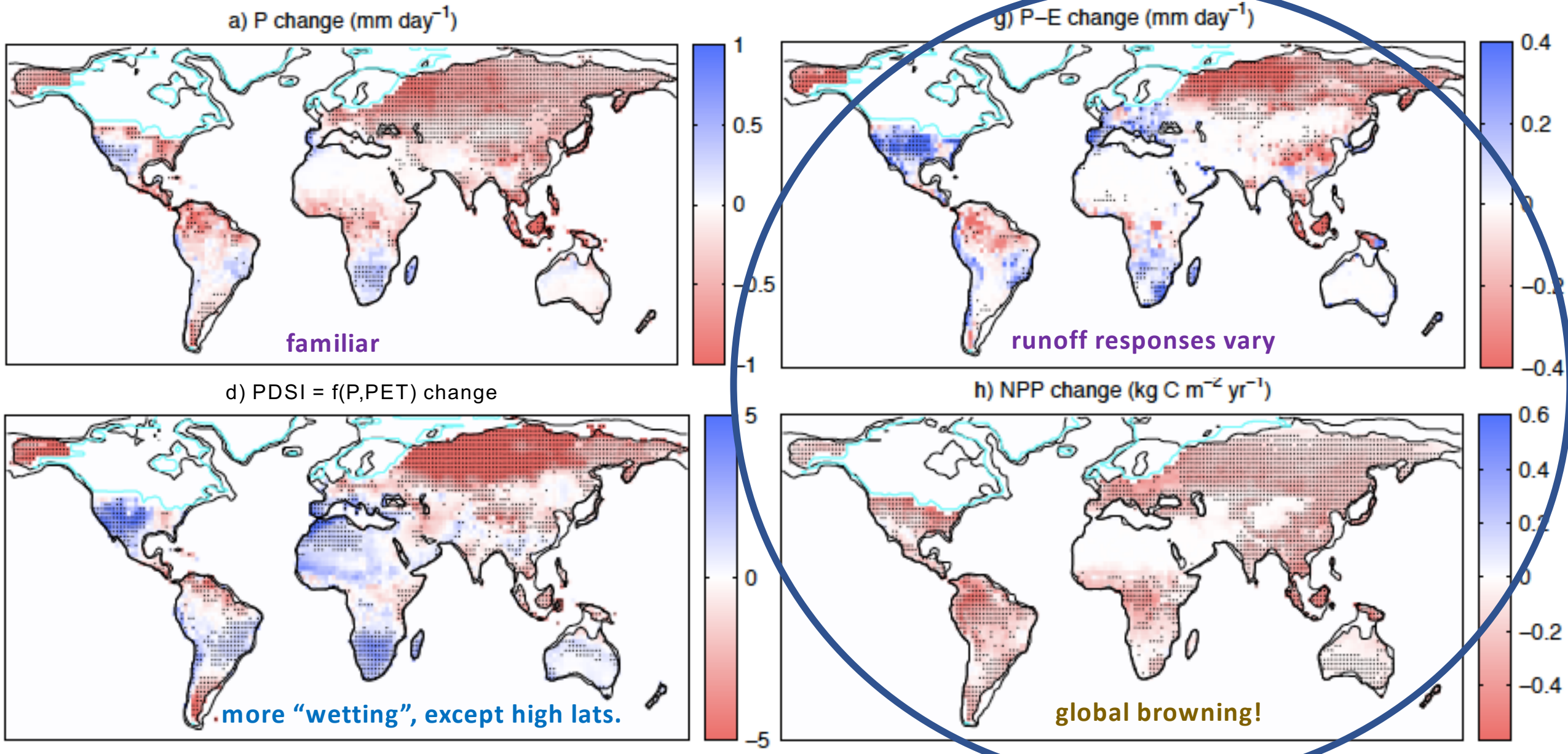

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  - (Quaternary-to-Pliocene warming was also green/wet, but for other reasons.)

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  - Indices are perhaps more relevant for fuel moisture/fire, if ~topsoil moisture.

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- So if you have a veg proxy (e.g. pollen, plant fossils, $\delta^{13}C$), it tells you about vegetation but *not necessarily hydrology*
- Likewise if you have a water proxy (e.g. lake level, water isotopes), it tells you about hydrologic system but *not necessarily plants/life*

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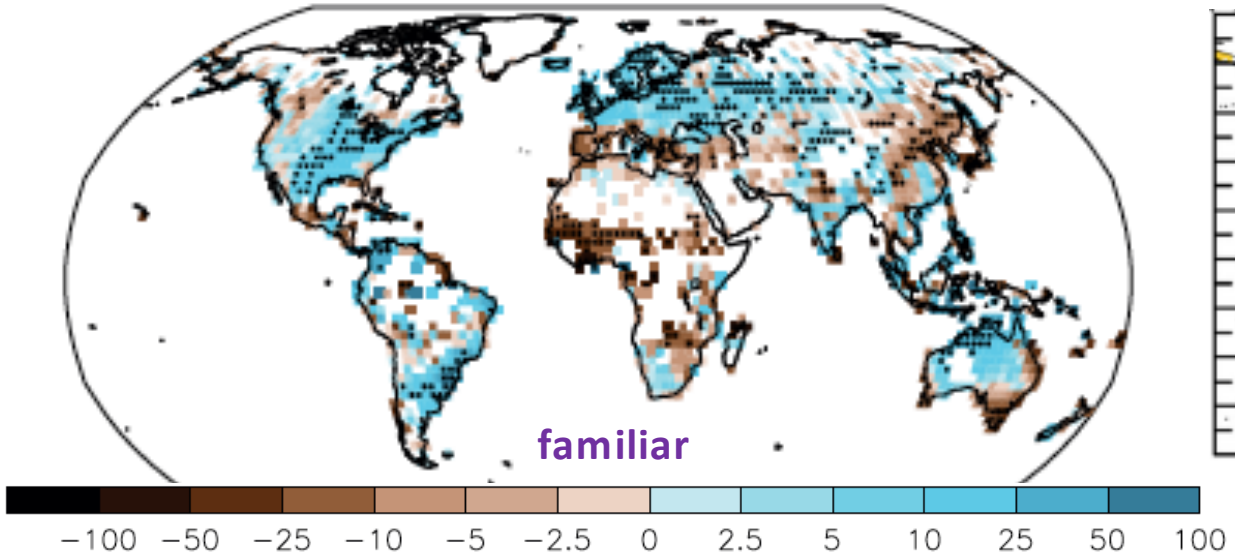
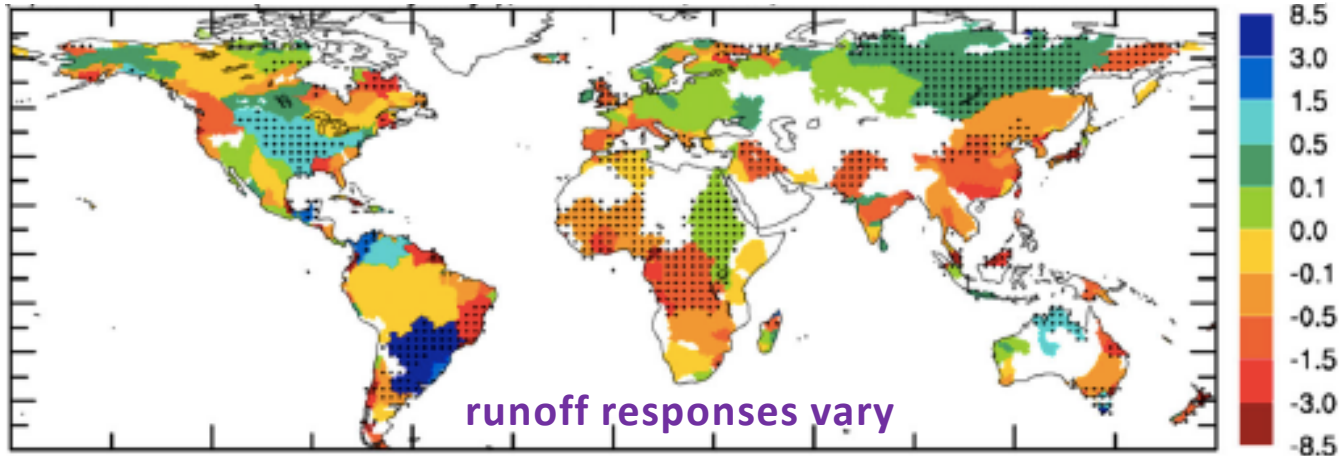
- Much less of a concern for e.g. precession, centennial variability.

Observed…

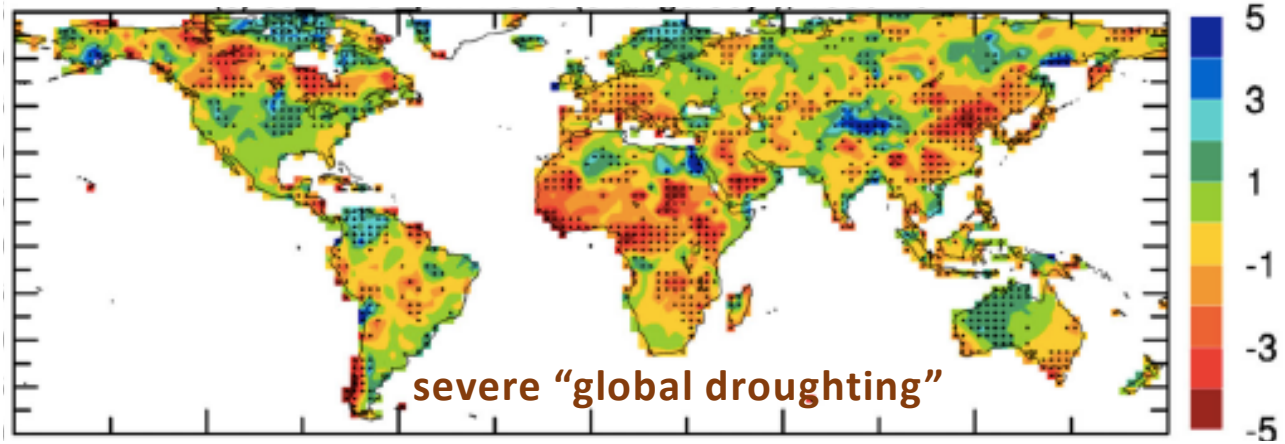
1951-2010 P trend (mm/yr per decade; IPCC 2013)



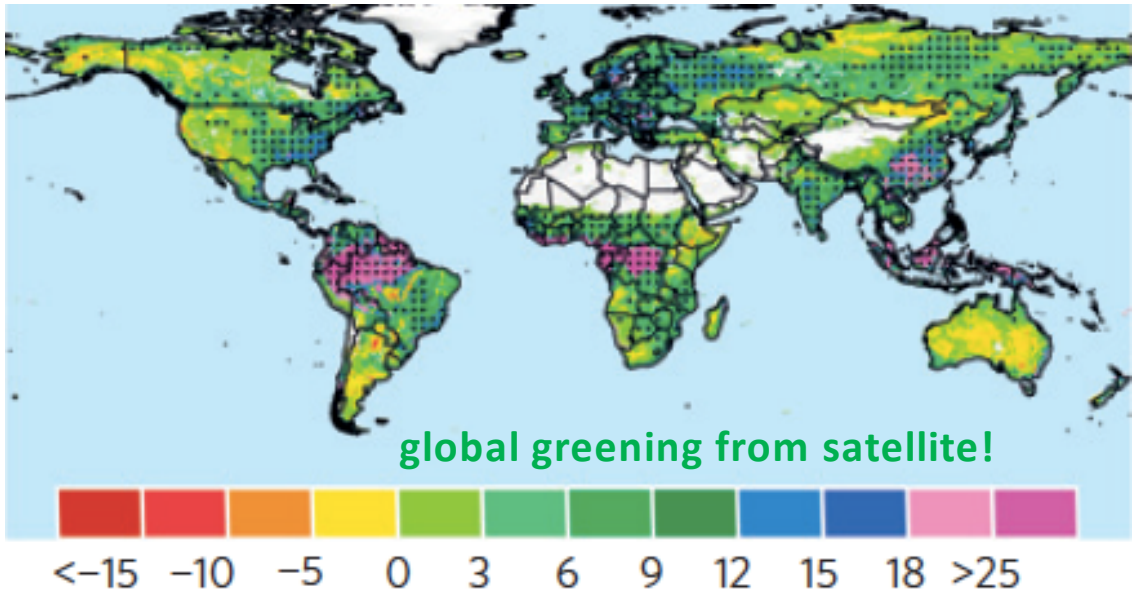
1949-2012 runoff trend (0.1mm/day per 50yr; Dai and Zhao 2016)



1950-2012 PDSI trend (PDSI per 50yr; Dai and Zhao 2016)



1982-2009 leaf area trend (0.1m2/m2 per decade; Zhu et al 2016)



(Stippling = trends are significant at 5%)